Fundamentals of

Operative Dentistry

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To

Our mentors

and

our parents

PREFACE

The first edition of *Fundamentals of Operative Dentistry* is unique in its own. Various contributors who have joined us in the preparation of this book express a coordinate philosophy in the approach to most modern concepts of operative dentistry.

This edition provides current diagnostic and treatment recommendations based on research, clinical experience and current literature. The information is relevant to contemporary science and practice of operative dentistry. This book is designed to help undergraduate dental students in providing efficient and superior dental health care among individuals. This book also gives experienced dentist to get the reference information on new development and techniques.

The new things which are added in this first edition are the Laser in operative dentistry, recent advances in composites and GIC, recent concepts in cavity preparation, management of deep carious lesions, compression between composite and GIC, biocompatibility of dental materials, biomechanics of cavity preparation, etc. These chapters will help the students to understand the matter of subject more clearly. Various diagrammatic presentations will further simplify the matter.

A textbook can be planned and written only with the supportive interest, encouragement, and tangible contributions of many people. Therefore, it is a privilege to acknowledge the suggestions of esteemed professors in the preparation of this text. The faculties of operative dentistry and other disciplines have contributed substantially to this work.

We extend our heartfelt thanks to all who played a vital role in helping us bring this project to a successful edition.

Balwant Rai
Jasdeep Kaur

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Fortunately, a very efficient teamwork from Dr Rajnish Jain and Prof (Brig) SC Anand always supported us with their valuable suggestions. The success of this work is not enterprise of a sole individual but a consolidated effort of group of committed members of our family Rajender Chawla, Yogesh , Tarun Singh and Rajesh Yadav who have left no stone unturned in collecting update information regarding the subject from the Internet.

Our special thanks to Dr Rajnish Jain, Dr Jigyasa Duhan for providing us some material for incorporation into the textbook. We are especially thankful to Dr Dinesh Chauhan and Dr Narender Rohilla for their contributions. We offer our humble gratitude and sincere thanks to our guide Prof (Brig) SC Anand and for his guidance during our undergraduation which helped us in writing this book.

We are also grateful to our parents and our relatives for their patience and support. We are thankful to M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, for publishing the book.

Lastly we offer our earnest prayers to God for endowing us the strength and confidence in accomplishing this endeavor to the best of our abilities.

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1 Cement and Tooth Colored Materials

Table 1.1A: Comparison of tooth colored materials

	Compressive strength PSI	*Tensile strength PSI*	*Flercre strength PSI*	*Modulus of elasticity*	*Setting shrink (V)*	*Hardness knoop*	*Water sorption*	*Solubility % in*
Enamel	40-56000	-	-	2.3	-	300	-	-
Dentin	36-50000	7500	-	12 millions	-	65	-	-
Silicate	24000-31000	700	-	3.1 millions	0.25	65	0	1.4-2
ASPA	23100-28000	650	-	1.9 millions	0.2	60	0.01	0.4
Unfilled resin	10-11000	4000	-	260000	7	16	7	0.1
Filled resin	8000	1500	1	100000	5	80	5	0.7
Corpo-rate resin	Ist - generation 45000 IInd-25000 Hybrid-55000	7000 6400 90000	10000 14000 16000	0.5	30-100	1.5	0.3	

Table 1.1B: Comparison of tooth colored materials

	Color stability	*Biologic form*
Silicate	None of these materials enamel are as color as tooth with age	1. Microleakage and disintegrated increase 2. Original acidity of cement which remain high upto one week
Unfilled and filled resins	–do–	1. High coefficient of thermal expansion 2. Exothermic heat of polymerization 3. Enamel etching acid accidentally applied on dentin.
Composite resin	–do–	1. Surface roughness allowing plaque accumulation especially around gingival margins 2. Leakage 3. The exothermic heat of polymerization
PSPA	–do–	1. Surface roughness that lead to plaque accumulation 2. Acidity of the original lingual and non-set matrix

Table 1.1C: Comparison of tooth colored materials

	Silicate cements	*Zinc phosphate*	*Zinc oxide-Eugenol*	*Glass ionomer*	*Calcium hydroxide*	*Zinc polycarboxylate*
Composition	*Powder* – alumina, silica, cryolite, sodium fluoride, calcium phosphate, calcium fluoride *Liquid* – phosphoric acid, aluminum phosphate or magnesium phosphate and water	*Powder* – zinc oxide, magnesium oxide, silica and other oxide *Liquid* – phosphoric acid, aluminum phosphate, aluminium zinc and water	*Powder* – zinc oxide, zinc stearate, white rosin, zinc acetate and magnesium oxide *Liquid* – eugenol and olive oil	*Powder* – alumina, silica calcium fluoride, aluminium fluoride, aluminium phosphate sodium fluoride etc. *Liquid* – polyacrylic acid and copolymer with iticonic acid, malic acid, tartaric acid, and water	*Base paste* – calcium sulphate, glycol salicate titanium doxide and calcium tungstate *Catalyst paste* – calcium hydroxide, zinc stearate, zinc oxide ethylene tolaesic and sulfonamide	*Powder* – zinc oxide, oxides of bismuth and aluminium, magnesium oxide and stannous oxide *Liquid* – polyacylic acid and copolymer of acrylic acid with other unsaturated carboxylic acid
Setting time	3-5 minutes	5-9 minutes	4-10 minutes	4-7 minutes	2.5-5.5 minutes	7-9 minutes
Mixing time	45 seconds- 1 minute	1-1.15 minutes	-	45 seconds	-	30-40 seconds
Compressive strength (MPa)	180	103.5	3-55	150	10-27	55
Tensile strength (MPa)	3.5	5.5	0.32-5.3	6.6	1.0	6.2
Hardness (KHN)	70	-	-	49	-	-
Thermal properties	Lower than other restorative material	Good thermal insulators	Excellent insulating properties	-	Sufficiently thick layer provide thermal insulation	Good thermal properties
Biological properties	- severe irritant - initial pH – 2.0 it will be below 7 even after one month	After 3 minutes mireing pH – 3.5 Neutral after 24 to 48 hours	PH-6.6 to 8.0 least irritating Bacteriostatic Obtundant	Mild pulpal response	pH – 9.2-11.7	Initial – acidic freshly mired cement – 3.0-4.0 After 24 hours – pH – 5.0-6.0

Contd...

Contd...

	Silicate cements	*Zinc phosphate*	*Zinc oxide-Eugenol*	*Glass ionomer*	*Calcium hydroxide*	*Zinc polycarboxylate*
Film thickness	-	Type-I – not more than 25 mm type-II – not more than 40 mm	Greater than 25 mm	-	-	-
Solubility and disintegration	It dissolves and disintegrates in oral cavity	Low solubility 0.06%wt	0.4%wt	Initial solubility high (0.4%)	0.4 to 7.8%	0.6wt
Powder/liquid portion	1.4 gm/4 ml	1.4 gm/0.5 ml	4/1 to 6/1 by wt	3/1 by wt	-	1.5/1 by wt
Manipulation	Liquid is dispensed just prior to miring	Stainless steel spatula is used in small margin cements brisk circulator motion	Circular motion on cool glass slab	Agateor plastic spatula used Finishing by folding method	Equal length of two pastes pricing on paste	Miring on a cooled glass slab
Clinical application	Intermediate restoration in caries active months. Esthetic restoration of anterior teeth	Temporary restoration. Cutting of restorations. Cutting of orthodontic bands and brackets High strength bases	Permanent cementation. Temporary cementation. Cavity liners. Temporary filling and thermal insulation	Liners and bases. For cutting. For restorations (anterior teeth in cervical area)	For direct and indirect pulp capping. Purification in young permanent teeth where root for motion in complete for direct and indirect pulp capping	Luting permanent restorations As bases and liners Used in orthodontics for cementation of bands

2 Direct Filling Gold

HISTORICAL BACKGROUND

The introduction of this material into dentistry was accidental and was an outcome of the Great Chicago fire in 1971. A book seller had gold foils in the book placed in a safe, following the fire the safe was opened and it was found that the foils were uncharmed except for charring that occurred due to shriveling of paper in an air tight environment and it was noted that this gold foil exhibited certain unique properties of cold welding.

This unique property of gold is made use of in dentistry and is responsible for its popular use in this field.

TYPES

Non-cohesive and Semi-cohesive

The manufacturer can subject the foil to a volatile agent such as ammonia, which is adsorbed on the surface of the gold. This volatile substance acts as a protective film to prevent adsorption of non-volatile materials and premature cohesion of pellets in their container. This is, i.e. ammonia treated foil is referred to as non-cohesive or semi-cohesive foil. Non-cohesive gold also has adsorbed agents like iron salt or an acidic gas (sulphur phosphorus containing groups) on its surface. The volatile film is readily (of semicohesive gold) removed by heating, thereby restoring the cohesive character of the foil. Non-cohesive gold is rarely used, but may be employed to build up the bulk of a direct gold restoration.

Reformed Foils

Now-a-days ropes and cylindrical are available in performed shapes. Both are made from No. 4 foil that has been carbonized or corrugated (i.e. placed between sheets of paper) and ignited in closed containers. This type of gold exhibits superior welding properties.

Laminated Gold Foil

When a cube of gold ingot is cold worked in order to formulate a sheet, the cubical crystals of gold will be stretched and elongated in a specific direction. If the gold foil of that cube is viewed under a microscope, it appears fibrous, with the fibers parallel to each other in a specific pattern. Mechanically speaking, this type of gold foil material will have directional properties, i.e. it will be resistant to stresses in one direction better than the other the idea of laminated gold foil is to combine two or three leaves of gold, each from different ingots which have been cold worked in different directions. Although each leaf will be directional in its properties, when combined together, they can be resistant in different directions, therefore laminated gold foil is definitely much stronger and much more resistant to stresses than the other forms of direct gold materials.

Platinised Gold Foil

This might be considered a laminated foil in which pure platinum foil is sandwiched between two sheets of pure gold foil. The layers of platinum and gold are bonded together by a cladding process during the rolling operation. Thus, the sandwich is already welded together before the beating begins. The objects of adding platinum to the gold foil is to increase the hardness of the restoration. This product is available only in No. 4 form.

Electrolytic Precipitate

Another form of gold for direct filling is crystalline gold powder formed by electrolytic precipitation.

Gold is precipitated through a process of atomization, i.e. the gold is melted and sprayed into cold compartment within an inert atmosphere. This causes the gold melt to precipitate in the form of spherical particles. After the automization process the gold particles are passed through different layers of sieves, larger holes of the sieves are at the top and smaller holes are at the bottom of the compartment. Thus, smaller particles will be precipitated at the bottom of the compartment and the larger particles will be deposited at the top of the compartment the particle diameters will range from 5 to 75 um.

Another way of precipitating gold is through electro-deposition, i.e. cathodic deposition of gold from an electrolyte via a suitable anode. Gold particles precipitated through such a process will not have the regular shape produced by automization, although they will range in diameter very closely to those produced by automization.

The powder is formed into shapes of strips by sintering. Sintering causes self-diffusion between particles, where they are in contact, so the crystals actually grow together. The temperature is much below the melting point of gold. Electrolytic precipitates are available as mat, mat foil and alloyed.

Mat gold: Mat gold is crystalline, electrolytically precipitated gold, formed into strips or cakes.

This is mainly obtained through electrodeposition, accumulated in the form of strips or cakes. Then they are subjected to a singering process, in which there will be surface diffusion of the atoms of the particles, creating minimal cohesion between the particles. They can then be transported cut to specific shapes. These strips are cut by the dentist into the desired size. Mat gold is preferred because it is easy to build up the internal bulk of the restoration, as it can be more easily compacted and adapted to the cavity. Gold foil is generally recommended for the external surface of the restoration. Thus, the mat gold is covered with a veneer of foil.

There is a greater tendency for voids that may appear as pits if it is used on the surface of the restoration, because the crystalline form of mat powder does not permit easy welding into a solid homogenous mass as gold foil does.

Mat foil: Mat foil is a sandwich of electrolytic precipitated gold powder sheet of No. 3 gold foil. The sandwich is sintered and cut into strips of differing widths. The dentist can thus cut these into desired lengths. Sandwiching mat between foil sheets was done to try to eliminate the need to veneer the restoration with a layer of foil. This type is no longer marketed.

Alloyed Electrolytic Precipitated

The newest form of electrolytic gold is an alloy of gold and calcium (0.1 to 0.5% by weight) called electrology for greater ease of handling, alloy is sandwiched between two layers of gold foil.

Calcium produces stronger restorations by dispersion strengthening, which locks in cold work strengthening. Thus, alloying with calcium alter the crystalline structure, so that the hardness and strength will be increased.

Powdered Gold: Since the middle of the 19th century, chemically precipitated gold powders have been available in agglomerated form. These agglomerates were usually furnished with liquid such as an alcohol or dilute carbolic acid, which hold the agglomerates usually disintegrated when compaction was attempted. So that the gold powder was enclosed in a Number 3 gold foil.

A fine powder is formed by chemical precipitation or by automizing the metal. This powder is a blend of powders of varying particles sizes (maximum – 74 mm, average 15 mm). The pellets are mixed with soft was, (which is burnt off later) and then wrapped with gold foil (No. 3), rather than sintering the mass, like for mat gold. The foil forms an effective container for the powdered metal and acts as a matrix throughout the mass, while it is condensed.

The powdered gold pellets have a cylindrical irregular shape and a diameter of 1 to 2 mm. The ratio of gold foil to powder varies from 1 to 3 for the smallest pellets to approximately 1 to 9 for the largest.

Some believe that the use of pellets of powdered gold increases cohesion during compaction and reduces the time required for placing the restoration. This is because each pellet contains 10 times, more metal by volume than are comfortable sized pellet of gold foil.

PHYSICAL PROPERTIES OF COMPACTED GOLD

i. **Strength:** Transverse of bending strength is most representative of clinical applications, as it is a reflection of all three types of stresses – compressive, tensile and shear. In direct filling gold, the failures occur from tensile stress, due to incomplete cohesion. Thus, transverse strength is a measure of cohesion.

ii. **Hardness:** Indicates the overall quality of compacted gold, low hardness indicators presence of porosity.

iii. **Density:** Apparent density is measured, due to the voids: physical properties.

The transverse strength, hardness and density are greater when gold foil is used alone or in combination with mat

Type	*Transverse strength*	*Hardness*	*Density*
Mat gold	161 to 169 Mpa 23000 to 21400 psi	52-60 KHN	14.3-14.7 gm/cm^3
Powdered Gold	155 to 190 Mpa 22000 to 27100 psi	55-64 KHN	14.4-14.9 gm/cm^3
Gold foil	265 to 296 Mpa	69 KHN	15.8-15.9 gm/cm^3
Mat gold & Gold foil	196 to 277 Mpa 29400 to 32400 psi	70-75 KHN	15.0-15.1 gm/cm^3

gold, as compared with other forms. This may imply better compaction of foil (and better cohesion) (but it is more probable that the operator or operators may have been prefamiliar with the use of foil than with the other forms). The use of mechanical condenser improves the hardness when mat gold and powder gold are used the difference in physical properties among the various forms of gold including the gold, calcium alloy and the method of compaction are not clinically significant. The physical properties are probably more greatly influenced by the competence of the operator in manipulating and placing the gold.

Restorations made with direct filling golds do not exhibit as high physical properties as those made with the dental casting alloys. Consequently they cannot be used to encompass a tooth (like a cast crown) or restore a cusp as they cannot withstand masticatory stresses. Therefore, the use of direct filling gold is generally limited to areas where the simply fill rather than veneer or reconstruct the tooth.

(iv) **Tarnish and corrosion Resistance:** Is good, there is very little marginal leakage between the filling and cavity walls, if the compaction is good.

(v) **Biocompatibility:** It is biocompatible and produces only a minimal pulpal response, if compacted properly. The technique, however, does involve a certain amount of trauma to the tooth and its supporting tissues. I smaller teeth this is an important consideration. The mechanical condenser causes less trauma than manual technique. Therefore, direct filling gold is not used extensively.

INDICATIONS FOR DIRECT FILLING GOLD (CLASS I, CLASS V, CLASS III, CLASS II AND CLASS VI)

a. Lesions with very limited dimensions and extent.
b. Lesions in which cavity margins can be located on sound enamel surface.
c. Lesions in vital teeth, i.e. having a sound pulp dentin organ, intact supporting periodontium and the ability to withstand condensation forces.
d. Lesions in which tooth structure left after removal of diseased tissues is bulky enough to create self-resisting walls and pronounced retention modes.
e. Lesions in patients with good oral hygiene, how caries and plaque indices.
f. Lesions with adequate access for detailed preparation and instrumentation.
g. Areas necessary to repair perforations in cast gold alloys restorations.
h. Teeth with no enamel crazing or microcracks.

Contraindications

a. In teeth with large pulp chamber.
b. Periodontally weakened teeth with questionable prognosis.
c. In handicapped, elderly or very young patients enable to sit for longer appointments.
d. Root canal treated teeth because of their brittle nature.

CAVITY PREPARATIONS FOR DIRECT GOLD RESTORATIONS

Class I Cavity Preparation (Fig. 2.1)

The outline form for the class I cavity preparation for compacted gold is extended to include the lesion on the tooth surface

Fig. 2.1: Class I cavity

treated. The outline may be a simple circular design for a pit defect, ablong or triangular or may take on a more extensive form if needed to treat a defective fissure. Cavity margins are placed at a depth of pit and fissure. All noncoalesed enamel and structural defects are included. The outline is kept as small as possible consistent with provision of suitable access for instrumentation and for manipulation of gold.

For a class I cavity preparations the surrounding walls of the preparation are parallel with each other; although in extensive occlusal preparations the mesial and or distal walls may diverge slightly occlusally to avoid undermining and weakening marginal ridges. The pulpal wall of uniform depth is parallel to the plane of surface treated, and is established at 0.5 mm into the dentin. The pulpal wall meets the surrounding internal walls at a slightly rounded angle created by the shape of the small undercuts may be placed in the dentin if additional retentive features are required to provide convenience in beginning the compaction of gold. Undercuts when desired, are placed facially and lingually in posterior teeth or incisally and gingivally on the lingual surface of incisors at the level of the ideal pulpal floor position. These undercut line angles must not undermine marginal ridges. A very slight cavosurface bevel may be placed; (1) To create 30 to 40 degrees metal at the margin for ease in finishing the gold and; (2) To remove remaining rough enamel. The bevel is not greater than 0.2 mm in width and is placed with a rotary stone or suitable finishing bur. The desired angle is sighted between the external tooth surface and the stone to determine where the bevel is needed.

Instrumentation: By use of high speed hand pieces with air water spray, the No. 330 or 329 (pear shaped bur) but is aligned and the outline and internal walls established. In extensive lesions a small hoe is used complete the desired degree of flatness of the pulpal wall. Small retentive undercuts are placed with 331/2 (inverted cone) bur or using a small angle former. Round bur is used to remove remaining caries. The preparation is completed by finishing the cavosurface with an angle former or a small finishing bur or flame shaped stone.

Class V Cavity Preparation (Fig. 2.2)

A. The Ferrier Design

The operating field: As with all DFG restorations, rubber dam must be placed to provide suitable dry field for class V restorative therapy. A gingival retractor can be used. The punching of rubber dam is modified to provide ample rubber between the teeth and to provide enough rubber for

Fig. 2.2: Class V cavity preparation

coverage and retraction of soft tissues on the facial side of the tooth. The hole for the tooth be treated is punched 1 mm facial of its normal position and an extra 1 mm dam left between the hole for the tooth to be treated and adjacent teeth.

Cavity Preparation

The typical cavity preparation for restoration with direct gold is trapezoidal which satisfies esthetic needs and requirements for retention and convenience forms. By this design the restoration is esthetically more pleasing and by virtue of this straight design excess gold is readily discern and removed during final stage. The gingival outline is shorter than the occlusal outline and both are parallel. The mesial and distal margins connect the gingival outline to the occlusal outline. The occlusal outline is straight and parallel with the occlusal plane of the teeth. It is extended occlusally to include the lesion. The extension mesiodistally will place the junction of the occlusal, mesial and distal outlines under the free margin of the gingival rendering it most esthetic. The gingival outline is straight and may be extended far enough apically to include the lesion and extends mesiodistally to the line angles of the tooth. The mesial and distal outlines are parallel to proximal line angles of tooth. The mesial and distal outline are straight lines that meets the occlusal outline in sharp acute angle and gingival outline in sharp obtuse angles.

The depth of the axial wall varies with the position of the preparation on tooth. The wall should be 1 mm deep in occlusal half and 0.75 to 1 mm deep as it approaches the cervical line. It should be placed in dentin and is occlusogingivally parallel to the facial surface of the tooth. Mesiodistally the axial wall is parallel to the facial surface of the tooth. This prevents encroachment on the pulp. Excessive curvature results in a preparation that is either too shallow in the center or too deep at proximal extension, thus failing to provide a flat wall against which compaction can be done. A subaxial wall may be necessary if caries has progressed. The axial wall meets the occlusal wall at right angle, which in turn meets the external enamel surface at right angle. The axial wall meets the gingival walls in a sharp acute angle created at the expense of gingival wall. The axial wall meets the mesial and distal walls is abtuse angle preventing undermining of enamel. The orientation of gingival wall is the key for retention form of the preparation. Retention is hereby provided by facial convergence of occlusal and gingival walls. If gingival margin is established on enamel, the cavosurface is bevel.

Instrumentation: The No. 33 ½ bur is used to establish outline form. A hoe is used to establish internal walls; establishing sharp internal line angles and finishing margins. A wedelstaedt Chisel is used to finish cavo-surface margins and plane the axial wall. Acute axiogingival angle is established using a hoe when needed wedelestaedt is used for gingival bevel. Hoe can be used.

B. Class V Preparation with a Proximal Pan Handle Extension

This cavity consists of two parts, a facial or lingual part same as previous design and a proximal part, parallelogram in shape as an extension from the facial or lingual in the proximal direction. In any event the margins of this extension should be placed so as to be accessible for preparation, condensation, finishing and polishing. The walls (occlusal and gingival) should be kept so as to follow the direction of enamel rods and should not undermine contact area. The junction between the axial walls should be rounded.

C. Class V with Uni- or Bilateral Moustache Extensions Occlusally

This design is used when any surface defects occlusal to the height of contour are continuous with class V lesion necessitating one or two extensions occlusally. This design resembles a moustache shape. The mesial and distal walls of extension will be perfectly straight ending at a point occlusally.

D. Partial Moon (Crescent) Shape Cavity Preparation

Some times, due to the very apical location of the height of contour or to the gingival inclination of the height of contour, or to the danger of the restoration affecting esthetics, the classical trapezoidal shape will be unacceptable, as it will be involving more than the indicated tooth structures in the cavity preparation. These situations demand a very curved gingival margin in continuation with the mesial the distal margins as if creating part of the circle. The occlusal margin of this modification should follow the height of contours so the general shape will look semilunar. This type of cavity preparation is indicated in upper, lower cuspids and in upper first premolar. In these preparations incisogingival width will be minimal or if the gingival margins are located subgingivally almost all of the restoration will be in gingival sulcus.

The internal angulation of the walls will be similar to other designs except there will be no demarcation between mesiogingival and distogingival walls. However, there will be definite angulation between proximo occlusal walls.

Class III Cavity Preparation for Direct Gold Restorations (Fig. 2.3)

A. Ferrier Design

This design is indicated if, after removal of all the diseased and undermined tooth structure, bulky, labial, lingual and incisal walls remain. This will enable creation of two planed labial and lingual walls and a pronounced boxed incisal retention form within a definite incisal wall. Furthermore, this design is indicated if the labial extension facilitates minimal extension of the cavity preparation labially. Because of these limitations, this design is more indicated for the distal proximal surfaces of anterior teeth than for mesial. The choice of this design is further facilitated if periodontium and bone support around the tooth the adequate to allow slight separation for access.

Shape: The Ferrier outline is triangular in shape involving about 2/3 to one half of proximal surface.

Margins: The labial and lingual margin should be within the corresponding embrasures and should have certain specifications.

Fig. 2.3: Class III cavity

a. Facially, the margin should be parallel to the calcification lobes.
b. The labial margin should be minimally extended, especially for mesial cavity preparations.
c. The labial margin should extend labially enough for restoration to reflect light towards the adjacent proximal surface.
d. The lingual margin should not encroach on the marginal ridge.
e. The gingival margin should be located ½ to 1 mm apical to free healthy gingiva, following a straight line labiolingually.
f. Incisal margin is always placed in contact area.

Internal Anatomy

Axial wall should be rounded, facial and lingual walls will have 2 or 3 planes one perpendicular to the tangent of the axial wall, another enamelo-dentinal plane following the direction of enamel rods and another enamel, partial bevel plane. If the incisal wall is in incisal third it will be 4 planed and if in middle third it will be 3 planed. The gingival wall also is 4 plane.

Pyramidal retention forms are given axiogingivolabially and axio-gingivo-lingually with their base towards cavity and apex facing dentin.

Instrumentation: With a ½ round bur using lateral cutting strokes and axial pressure, remove tooth structure to the proper depth (0.2 mm from DEJ) within specified outline, then use the base of inverted cone bur (33 ¼) with incisogingival strokes to former the lingual wall with labiolingual strokes formulating the gingival wall. The side of the inverted cone bur can be used in inciso-gingival movements formulates the labial walls. Spear line is used to create retentive grooves gingivally and incisally.

A hatchet is used to box up the incisal retention form. An angle form is used to give gingival short partial bevel. A wedelstaedt chisel is used in the labial and lingual cavosurface margins to place bevel.

B. The Loma Linda Design

This design is indicated for a combination of powdered gold built up with a cohesive gold foil veneer. It is used when access to the lesions lingual, as dictated by esthetics and the caries extend or when the lingual marginal ridge is lost or undermined. When there is concern about esthetics, this cavity preparation may have its labial margin in contact area.

General shape: The proximal part of this cavity design will be triangular with rounded corners. The lingual part may have an incisal or gingival turn as dictated by access and resistance form.

Margins: Gingival margin is placed, 5 to 1 mm apical to marginal gingival labial margin is located in contact area or sometimes in embrasure area. Lingual margin is located far lingually to include marginal ridge and to facilitate access to internal parts of cavity.

Loma Linda design will have a more rounded line and point angles as compared to Ferrier design and the incisal retention mode appears bulkish than Ferrier design.

The labial wall will be 2 planed if in contact area of 3 planed if placed out of contact area or will be similar to that in Ferrier design if in embrasure area. This design will have 2 retentive cylindrical grooves. Labiogingival axially and linguo-gingivo-axially, 1.5 to 2 mm into dentin and one retentive cylindrical groove incisally directed incisolabio-axially.

Instrumentation: Using a ½ round bur from a lingual access, remove tooth structure within the contemplated outline at a minimal depth, using axial pressure and lateral dragging. Then with the base of the 33 ½ bur create a labial and a gingival wall form or lingual access using incisogingival and labiolingual strokes respectively. Use the side of the inverted cone bur to create a lingual wall placing the lingual wall placing the lingual margin on the lingual surface. Round bur is used to prepare retentive groove. A linear cutting edge of an angle former is used to create different planes for labial and lingual walls and to round off axial wall. Finally angle former or a Weidesteadt chisel is used indirect cutting strokes to make sure that gingival and incisal walls are 2 planed, devoid of frail enamel and have short partial enamel bevel.

C. The Ingraham Design

This preparation design is indicated primarily for incipient proximal lesions in anterior teeth where esthetics is the main concern. After removal of diseased and undermined tooth structure, this preparation design will accommodate bulky gingival and incisal walls. Good oral hygiene, low caries and plaque indices indicate this design.

General shape: Simple parallelogram.

Margins: Labial wall in labial contact area. Gingival margin is in gingival embrasure without any relationship to the gingiva. Incisal margins in contact area. Lingual margin is on lingual surface partly on the marginal ridge.

Internal Anatomy

The gingival wall will have 3 planes an inner dentinal plane, an outer enamelo-dentinal plane following the direction of enamel rods and peripheral partial enamel bevel plane. The axial wall will be flat, incisal wall is similar to gingival wall in reverse direction.

At the expense of each of the incisal and gingival walls there is a triangular area, the base of which is at the very labial end and tip at the lingual third of the cavity preparation. The deepest part will be located labially and decreased in depth proceeding lingually.

Instrumentation

Using No.: 168 bur from the lingual access, apply axial and labial pressure incisogingivally to remove tooth structure within the outlined plane. Hatchet is used to flattern gingival and incisal wall, it is also used to flatten labial wall and place it in proper angulation.

Round bur is used to give retentive modes. Marginal trimmer is used to accentuate incisal, gingival retention, to sharpen labioaxial, gingiovoaxial and incisoaxial line angles. The same instrument is used to create short partial bevel.

Class II Cavity Preparation for Direct Gold Restorations (Fig. 2.4)

A. Conventional Design

Shape: Similar to class I simple cavity preparation in molars and premolars. The isthmus will have "S" shaped outlines facially and lingually. The proximal portion will have one sided inverted truncated cone at the expense of functional cusp.

Margins: Same as simple class I, margins on the occlusal surface will be one inclined

Fig. 2.4: Class II cavity

planes of cusps and ridges. There is no need for dove tail preparation. The isthmus portion will have margins on inclined planes of remaining marginal ridge so that the cavity width will not exceed 1/5 the intercuspal distance.

The facial and lingual walls of proximal box will be 4 planed. An inner dentinal plane (Acute angled with tangent to the axial wall), a transitional dentinal plane, an enamelo-dentinal plane following the direction of enamel rods and peripheral enamel bevel plane.

Various cross-sections should indicate the existences of triangular shaped retention area at the expense of the dentinal portion of the facial and lingual walls of the proximal part of the cavity. The base of this triangle is at the gingival floor level and tip at the pulpal floor level. The retention triangle will open with it is widest side to the main part of the proximal cavity preparation, the narrowest side will be internally located.

Instrumentation

Similar to that for class I cavity preparation, smaller instruments are used.

B. Conservative Design

General shape: Same as for conservative class II for amalgam.

Margins anatomy: The axial wall is more slanting formed of enamel and dentin. Enamel portion is beveled towards the occlusal. Gingival floors is in 4 planes, an internal reverse bevel plane, making an acute angle with axial wall and of dentin, a transitional plane also formed of dentin, an outer enamelodentinal plane following enamel rod direction and peripheral enamel plane forming partial bevel.

The triangular areas facially and lingually, will extend to just short of occlusal enamel, leaving a limited thickness of dentin to support the occlusal enamel. The triangular areas join the reverse bevel internally via a rounded junction.

Instrumentation

Similar to that for class design 3 amalgam.

C. The Simple Design

General shape: Similar to that for amalgam except it has a more angular junction between the different margins.

Margins: Can be located anywhere since the whole surface is self-cleansable.

Internal Anatomy: The occlusal wall is formed of 3 planes (when occlusal margin is in occlusal 3rd). One plane in the form of dentin at right angle to axial wall, a second plane inclining occluso-proximally and formed a enamel and dentin and 3rd enamel wall in the form of bevel. If occlusal margin is in middle 3rd, it is made of 2 internal planes, perpendicular to the tangent of the axial wall. One, following direction of enamel rods, axial wall is flat.

Gingival floor has 4 planes. The inner plane formed of dentin in the form of reverse bevel making acute angle with axial wall, next is a transitional plane formed completely of dentin, 3rd plane formed of enamel and dentin following the direction of enamel rods. The final plane is the partial bevel plane.

The facial and lingual walls will have 3 planes or dentinal plane at right angle to the axial walls, an outer enamelodentinal plane following the direction of enamel rods and 3rd plane forming enamel bevel. If facial and lingual walls are in middle 3rd of the proximal surface, two internal planes can be combined into one, following the direction of enamel rods.

If access is obtained either facially or lingually, the non-access wall will have same planes as mentioned earlier, access wall will have only 2 planes, an enamelo-dentinal plane making obtuse angles to the axial wall and second being partial bevel plane.

DESORBING OR DEGASSING AND DECONTAMINATION

The primary reasons that direct gold materials are so convenient for building restorations is that they can have complete cohesion of space lattices at room temperature by simply bringing two pieces together and applying pressure to facilitate the cohesion process.

It is only necessary to remove any contaminants from the gold surfaces, so that it is possible to create more proximity between the gold pieces, to remove these contaminants direct gold material should be subjected to a process called degassing or decontamination, which is accomplished simply by applying some thermal energy that can introduce molecular motion in those contaminants, vaporizing them off the surface.

OBJECTIVES OF DECONTAMINATION PROCESS

i. To drive impurities off the surface, thus making the surface ready for cohesion and
ii. To keep this surface devoid of any other impurities until complete cohesion occurs during building of the restoration.

Direct filling gold can be heated in bulk or piece by piece.

Pieces of gold are heated over gas flame or electricity. When heating powder gold, complete burning of the wax should be ensured. When heating in bulk on tray, excessive amounts should be avoided, since the difficulties arising from prolonged heating can arise, from repeated heating as well.

Degassing can be accomplished in one of the 3 ways.

a. By an open alcohol flame
b. A mica over a flame
c. Electric degassing

By an Open Alcohol Flame

With this method it is important to use the middle zone of the flame (the high energy reducing zone). Each piece of gold is held in such a zone for 3 to 5 seconds before inserting it into the cavity. Care should be taken that alcohol should be pure methanol or ethanol without additives.

Advantages of Flame Desorption are:

- Ability to select a piece of gold of the desired size
- Desorption of only those pieces used
- Less exposure to contamination between time of degassing and use.
- Less danger of oversintering

Under heating should be avoided because it does not adequately remove the impurities and thus results in incomplete cohesion. This may be due to the remaining impurities or due to the carbon deposited by the flame leading to pitting and flaking of the surface.

A Mica over a Flame

A sheet of mica can be used over any type of flame and is used somewhat as a heating element. The surface of the mica is divided into several areas to indicate the time the pieces of gold were put on the mica. Maximally, five minutes are allowed for any piece of gold to be heated on the mica.

Electric Degassing

This is the most controlled and standardized way of decontaminating gold with this instrument, the heated compartment area is made of aluminum. An electric heater controls the time and the temperature. The surface of the heater is divided into small compartment, each accommodating a piece of direct gold. This eliminates the possibility of cohesion of the pieces before they are inserted into the cavity. Maximally 5 minutes are allowed for any piece to be kept in the electric decontaminator. Temperature used in between 340°C and 370°C.

Temperature below 315°C are not adequate to attain optimal hardness of compacted gold foil.

Hazards of Overheating of Direct Gold Material

a. The first hazard is the possibility of re-crystallization and grain growth. If this occurs, the mechanical properties of the material will drop substantially, recrystallization and grain growth are always functions of time and temperature. Therefore, minimal time and temperature to achieve the objectives of decontamination should be used.
b. Second hazard will be possible incorporation of impurities from the surrounding atmosphere in the melting or just the very hot surface of gold when it is overheated or the adhesion of those impurities to the gold surface when it is energized by too much heat for too long a time. Precautions should be taken not only control the time and temperature but also to avoid degassing the gold in a polluted atmosphere.
c. The third hazard can occur in gold materials that are supplied in a sintered form overheating during degassing can create an oversintered situation. So that instead of only surface atoms adhering to each other, the whole mass of the particles will adhere to each other. This situation can interfere with the plasticity of the material when it is inserted into the cavity.
d. Fourth hazard is the complete melting of the surface of gold which can make it completely non-cohesive.
e. Fifth hazard especially during mass decontamination of direct gold is that the pieces may tend to adhere before inserting them in the preparation. This is especially likely to happen if they are on mica without being sufficiently spaced form each other, and may lead to larger pieces which are difficult to condense properly.

Incomplete degassing can also create some unfavorable to actions, especially the incomplete removal of the protective gases thereby making the material only partially cohesive. This will create pitting and porosity within the final restoration.

COMPACTION OF DIRECT FILLING GOLD

Objectives for condensation of direct gold materials:

i. Wedge initial pieces between dentinal walls, especially at starting points this is the first and most important step in building a direct gold restoration, for as soon as these pieces are positioned, it is possible to build the restoration over them.
ii. Weld the gold pieces together by complete cohesion of their space latices.
iii. Try to minimize the voids in general, and to eliminate them from critical areas like the margins and the surfaces. If complete cohesion of the pieces at every area

occurs, there will be no voids. However, gold increments can bridge air entrapments and these may be exposed during finishing or polishing, creating pits on the surface. If such voids occur at the margins or in the interface between the tooth structure and the gold, microleakage will increase, followed by a recurrence of decay.

iv. Strain hardening of the gold materials which is due to the cold working during condensation. The resulting distortion of space lattices, interfaces with slip movements and consequently enhances the mechanical props. In fact some properties are tripled by condensation.

v. Adapt gold material to the cavity walls and floors, part of the condensation energy is consumed in bringing the material as close as possible to the cavity walls. This improves frictional retention, decreased microleakage and reduces recurrence of decay.

vi. Elastically deform the dentin of the cavity walls and floors, this objective is facilitated by the elasticity and the high modules of resilience of vital dentin. As soon as dentin is stressed it will be elastically deformed, yet it will regains original dimension after varying periods of time, when the direct gold material completely seals the cavity preparation. The return to normal grips the restoration, even more enhancing the frictional retention. Platinum loop is used to carry the material to the cavity.

Modes of Condensation

1. Hand instrument condensation: The condensation energy produced by this method is not always sufficient to fulfill the objectives of condensation. However, it can be used only as a first step in at two step condensation process, simply to effect the initial confinement of the material within the cavity.
2. Pneumatic condensation: This method involves the use of vibrating condensers energized by compressed air. Controlling the air pressure allows adjustments in the frequency and amplitude of the condensation strokes. Although an effective way, this is not completely controllable.
3. Electronic condensation: This is the most efficient and controlled way of condensing direct gold materials. The vibrating condenser heads can have an intensity or amplitude from 2 to 15 pounds and a frequency of 360 to 3600 cycles/minute. The typical apparatus easily permits controls of such variable.
4. Hand condenser and mallet: Although this is the oldest way of condensing direct gold materials it is still being used. It requires a trained assistant to apply the condensation energy with the mallet. This, must be incoordication with locating the hand condensers by the operator to the inside of the cavity preparation.

Gold Condensers

Direct filling gold condensers have faces that are serrated with pyramidal shaped configurations. This system has three functions.

a. Increase the surface area of the condenser face.
b. Act as swagger, thus creating lateral forces which will help in fulfilling the objectives of condensation.
c. Establish some triangular indentations in the condensed piece of gold so that the succeeding increment of gold may be interlocked and immobilized in these indentations.

Different Shapes of Direct Filling Gold Condenser

a. Round condensers (the bayonet condenser) are used mainly to start the DFG restorations and to establish ties in the inner parts of restorations.
b. Parallelogram and hatchet condensers (Parallelogram condenser perpendicular, hatchet parallel to shank) are used for preliminary condensation to create the bulk of the restorations.
c. Foot condensers are used mainly for cavosurface condensation and surface hardening of the restoration as well as for bulk build up.

Condensers for mechanical condensation can be praided for a contrangle or for a straight handpiece. They can be monangled, biangled or bayonet shanked or even with no angles in their shank.

Principles of Condensation (Figs 2.5A to C)

Any deviation from principles leads to immediate failure. These principles are:

1. The forces of condensation must be 45° to cavity walls and floor, i.e. they should bisect line angles and trisect point angles. This leads to maximum adaptation of gold against walls, floors, linear and point angles, with minimal irritation to the vital pulp dentin organ.
2. Forces of condensation must be direct at 90° to previously condensed gold. This avoids shear component that can displace or loosed the already condensed pieces of gold.
3. Whenever condensing a piece of direct gold, always start at a point on one side and proceed in a straight line to another point on the opposite side, then back to the original side on a different straight line, also starting at and arriving to a specific points. This ensures that the condenser has covered the entire surface of that pieces of gold. During these movements, the condenser should overlap at least ¼ of the previously condensed area. This further assesses that each portion of the gold increment has been welded and cold worked and that there are no voids present. This process called stepping

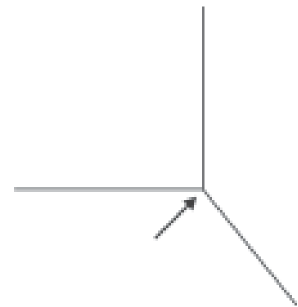


Fig. 2.5A: Trisect point angles

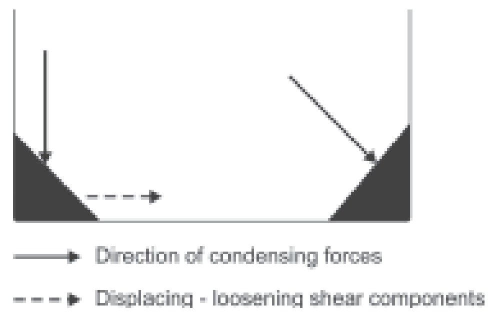


Fig. 2.5B: Direction of condensing forces and displacing-loosening shear components

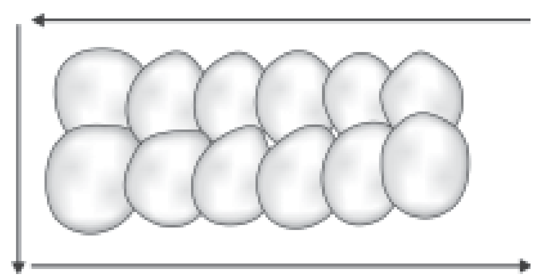


Fig. 2.5C: Stepping

ensures the maximum adaptation of the gold to the cavity walls.

4. Use the minimal thickness of pellet possible, provided that the condensers will not penetrate it. The thinner that the cross-section of each increment is, the easier will be the fulfillment of the objectives of condensation.
5. Energy of condensation: Energy used in condensing direct gold restorations should only be dissipated in fulfilling the objectives of condensation. Additional energy introduced to the field of operation might be consumed in deforming tooth structure of investing tissues of the tooth. Knowing that energy is a product of mass or weight, velocity and time, it is possible to control the amount of energy introduced.

   Generally speaking, it is more effective to utilize a lesser amount of energy inside the cavity preparation and to increase energy condensation gradually as the step by step build up proceeds to the surface. Thus, maximum energy will be used on the surface of the restoration. Condensation energy may be increased by increasing either the frequency or the amplitude of the condensing instrument, and by decreasing the size of the face of the condenser. Condensation energy is inversely proportional to the square of the surface area of the condenser.

   The most important item in the energy dissipation and tissue reaction towards it is the nature of the resistance to that energy. Such resistance is affected by many variables.

   a. The more tone that there is in the periodontal ligament, the healthier the periodontal ligament, the more resistance there will be to the condensation energy and more effective this energy will be in fulfilling the objectives of condensation.
   b. The volume of the tooth being condensed. Logically, the more that the volume of the tooth is, the more will be its ability to absorb energy without deformation and the more will be its ability to resist this energy, allowing fulfillment of the objectives of condensation.
   c. The modules of resilience. The higher that the modulus of resilience of the tooth in which the condensation is occurring (e.g. Vital dentin) the better will be its resistance to deformation).
   d. Design factors: Bevelled cavosurface margins or edges are more resistant to deformation than angular ones. Also flat floors and walls are more resistant to deforming energy than inclined ones.
   e. Operator variables: The operator is the one who decides what type of energy and at what velocity and amplitude it should be used at different stages of building up the direct gold restorations.
   f. Increment size minimally sized increments are more effective in realizing the objectives of condensation than larger increments.
   g. Technique variables: It helps, especially when using precipitated direct gold materials, to seat the material first, immobilizing it in the cavity preparation, before starting the process or mechanical condensation. This minimizes the loss of gold and helps assure the proper direction of forces against the gold resisting tissues. During the incremental build up it is good to

periodically check for porosity within the restoration, simply by pressing in with a sharp explorer and by feeling for any deficiency in the condensation or improper coverage of cavosurface details. It is easier to correct the condensation procedure and to add more increments to fill in these deficiencies at this time than later.

6. When inserting pieces of direct gold material, condensation can be either from one periphery of the increment to the other or preferably from the center of the increment to the peripheries, using the latter method of condensation will minimize, bridging trapped air bubbles that will culminate as surface deficiencies in the final restoration.
7. The condensation of precipitated types of direct gold materials should be started by hand. A piece of mat gold (electro alloy) coinciding with the shape of the preparation should be seated in the cavity, or several balls of gold dent necessary to cover the cavity floor or axial wall should be seated rupturing their cavering. Then hand condensation is started in the form of a rocking action, preferably from the center to the peripheries, following the same direction of forces and the principles of condensation previously mentioned. When the material is unyielding to the hand condense, mechanical condensation can placed.

METALLURGICAL CONDENSATION

A. Metallurgical consideration of cohesive gold foil
B. Metallurgical consideration of mat gold restorations
C. Metallurgical considerations of powered gold restorations

Metallurgical Consideration of Cohesive Gold Foil

A cross-section of a properly condensed cohesive gold foil will demonstrate the following feature in a metallurgical microscope.

1. The superficial 400 to 600 microns are formed almost completely of solid gold with no voids. It has been proven that this layer of solid gold is mainly due to the act of burnishing.
2. The deepest 200 um in contact with a floor also is composed of solid pure gold with minimal voids. This is due to the resistant nature of the walls or floors against which the gold has been condensed.
3. Serrated portions exist in the bulk of the restoration, with isolated areas of solid gold ranging from 3 to 4 microns in thickness corresponding to the serrated condense faces. These are areas with no or minimally sized voids.
4. The reminder of the restorations is full of voids, varying in size and number from one location to another.

Metallurgical Considerations of Matt Gold Restorations

In a microscopically viewed cross-section of a mat gold restoration the following features are apparent. There will be no areas of solid gold, i.e. voids will be spread throughout the restoration even at the surface, only strips of solid gold foil portion of the mat foil for this reason, mat gold should always be veneered with cohesive gold foil in order to prevent porosity from occurring at the surface.

Metallurgical Considerations of Powdered Gold Restorations

As in mat gold, powdered gold restorations when viewed, microscopically in cross-section will be full of voids, only scattered, thin area of solid gold will be found within the restoration, corresponding to the gold foil encapsulating sheets. Therefore as with mat gold, it is necessary to veneer powdered gold with cohesive gold foil, in order to establish solid gold coverage on the surface and at the margins of the restoration.

General Steps for Reinsertion of Direct Gold Restoration in a Cavity Preparation

General outline of procedures of insecting DFG into cavity;

A. 3 step build up of the restoration
B. Paving of the restoration
C. Surface hardening of the restoration
D. Burnishing
E. Margination
F. Burnishing
G. Contouring
H. Additional burnishing
I. Finishing and polishing
J. Final burnishing

Three Steps Build Up of the Restoration

1. Tie Formation (Fig. 2.6A): This involves connecting two opposing point angles or starting points filled with gold with a transverse bar of gold such a tie form the foundation for any restoration in direct gold. Of course it resistance to displacement should be tested before proceeding to the next step.
2. Banking of walls (Fig. 2.6B): This is accomplished by covering each wall from its floor or axial wall to the cavosurface margin with the direct gold material. A wall should be banked in a way that will not obstruct tie formation or banking of other walls in the cavity preparation. Banking should be performed simultaneously on the surrounding walls of the preparation.
3. Shoulder Formation (Fig. 2.6C): Some times to complete a build up, it is necessary to connect two opposing walls with the direct gold material. These 3 steps should completely fill up the cavity preparation, but the build up should continue until the preparation overfilled.

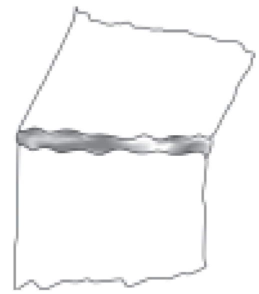


Fig. 2.6A: Tie formation

Fig. 2.6B: Banking of walls

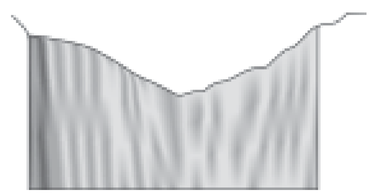


Fig. 2.6C: Shoulder formation

Paving of the Restoration

Every area of cavosurface margin portion should be individually covered with excessive gold foil. For this procedure a foot condenser is useful.

Surface Hardening of the Restoration

Utilizing the highest condensation energy in the restorative procedures (i.e. a high frequency and low amplitude), go over the surface of the restoration in all direction so as to strain harder, the surface gold and to fulfill the rest of the condensation objectives at this critical area (surface) of the restoration.

Burnishing

As mentioned before, burnishing is the major act in creating a solid gold sheet marginally land on the surface. Burnishing should be done with proper instruments, moving from gold to tooth surface. Not only will this procedure enhance surface hardening, but it will also adapt the material more to the margins as well as eliminate surface and marginal voids.

Margination

Using sharp instruments (e.g. Knives and files) moving from the gold surface to the tooth surface, try to eliminate excess in small increments at a time. Care should be taken not to displace or cut a big chunk of direct gold marginally, as this may displace the whole restoration or cause irreversible damage marginally. The margination process is done until it is possible to visualize the original outline of the cavity. It may be necessary to alternate between burnishing and margination because margination may expose soft gold or voids. Burnishing can correct these small discrepancies.

Burnishing

This process definitely follows margination as a means of closing marginal discrepancies as well as strain hardening the surface.

Contouring

In this process an effort is made to create the proper anatomy of the restoration to coincide with that of the tooth and to be compatible with that of the opposing contacting and occluding teeth. It is established using knives, files or finishing burs. If contouring involves margins, they should be reburnished before final contouring further burnishing of non-marginal parts of the restoration may also be needed during the contouring procedure.

Additional Burnishing

This is done for the purpose of fulfilling same previous objectives.

Finishing and Polishing

Minimal finishing and polishing will be required with a properly surface hardened, marginal and contoured restoration. However, some finishing may be done using precipitated chalk or tin oxide powder on soft bristle brush or rubber cups.

Final Burnishing

This is done to ensure closer to marginal voids and other surface discrepancies.

Biocompatibility of Direct Filling Gold Restoration:

- As irritant to the pulp dentin organ.
- Its effect at different effective depths.
- Protective bases necessary.

As an irritant to the pulpdent organ. The irritating factors are;

Condensation energy: The energy of condensation not absorbed by the restorative material is dissipated into the vital dental tissues creating deformities which may lead to irritation in the pulp dentin organ. It has been verified that condensation energy forces at right angles to the axial walls or pulpal floor are the most destructive to the pulp dentin organ. Therefore, the operator should use forces 45° to those walls in an effort to avoid deleterious effects.

The thermal energy: The thermal energy in the gold pellet exceeding that necessary for decontamination will also be transmitted to the pulp dentin organ. The Frictional heat of finishing and polishing:

The galvanic currents: The galvanic currents established between cathodic gold and other metallic restorative materials.

- Ultrasonic energy resulting from high condensation frequencies can create reversible harm to the pulp dentin organ.

Effect of Direct Gold Restorations at different effective depths:

- With an effective depth of 3-3½ mm a normal pulp will undergo a healthy reparative reaction.
- With an effective depth of less than 1 mm there will usually be destruction in the pulp dentin organ. Initial sign is usually cracking in the pulpal or axial wall.

Protective Bases Necessary for the Pulp Dentin Organ

With an effective depth of 3 mm or more no intermediary base protection will be necessary.

With an effective depth of 2 mm or more cavity varnish should be applied on all walls and floors, with exception of cavosurface margin.

If the effective depth is between 1.2 mm a subbase of calcium hydroxide or unmodified ZOE is indicated. This sub-base should be covered with a layer of varnish and then a base of zinc phosphate cement. Conditions of the pulp allow calcium hydroxide as a subbase, polycarboxylate cement may be used as the overlying base. With an effective depth of less than 1 mm DFG restoration are contraindicated.

DFG restorations are most efficiently sealing permanent restorative materials. Not only does the microleakage space have least dimensions, but also decreases with time. This is because of the method of condensation creating elastic deformation of the underlying and surrounding dentin, nobility of the material, the strength especially in very thin cross-sections and complete insolubility of material in oral fluids.

STEP F GOLD

A new direct gold material that is considerably different from other direct golds has been available since 1989. The advantages of this material are that the final restoration exhibits greater density than other forms of granular gold and has a 50% increase in shear strength when compared to gold foil.

Direct gold has been classified into gold foil, mat gold, powdered gold and alloyed. A new type of DFG was introduced to the dental profession in 1989 that morphologically differs from the types previously available. This material was first available in Germany but more recently has been introduced in US under the name of step F gold (translation from German direct filling Gold).

According to the manufacturers, this new type of filing gold is produced from chemically precipitated gold powder that underwent a milling process after precipitation. The individual particles are then loosely sintered together and cut into strips 3 mm wide and 40 mm in length. This is available in 3 thickness, 0.7 mm, 1 mm and

1.5 mm. The amount of gold in each strip is approximately 8% of volume of the strip.

Research by manufacturer has demonstrated a 50% increase in shear strength of this material compared to conventional compacted gold foil. It has been demonstrated that condensed step F gold produced fewer porosites than either mat gold foil or electroalloy.

CONCLUSION

Gold in one form or another has been used for many years as a dental restorative material. Its early use was related to the fact that it was available, workable, tarnish and corrosion resistant and could be obtained in pure and full metal without complicated techniques.

However, it has fallen in popularity considerably over the past 4 decades, in part because of environment concern about amalgam and the limitations of composites, glass ionomers and ceramics.

Compared with other materials, properly inserted direct gold restorations provide a reasonable long clinical service. With the variety of forms that are now available and the modern equipment for manipulating and compacting the gold, the time involved in placing the restoration has been reduced. The concern for a possible damaging effect on the pulp has been disputed. Apparently, direct gold that is compacted properly into sound tooth structure produces only a minimal pulpal response.

However, the technical skill of the dentist is of paramount importance to success. A direct gold restoration of poor quality can prove to be one of the most inferior of all clinical restoration. The proper insertion of a direct gold restoration challenges the technical proficiency of dentist, as does no other type of restoration.

3 Pain Control in Operative Procedures

Definition

Pain can be defined as a unpleasant sensational experience initiated by noxious stimulus and transmitted over a specialized neural – network to the CNS where it is interpreted as such.

Theories of pain (Figs 3.1A and B)

1. Specific theory
2. Pattern theory
3. Gate control theory (Fig. 3.2) – Most accepted theory proposed by Melzak and Wall

TYPE OF PAIN BY NATURES

Pain Perception

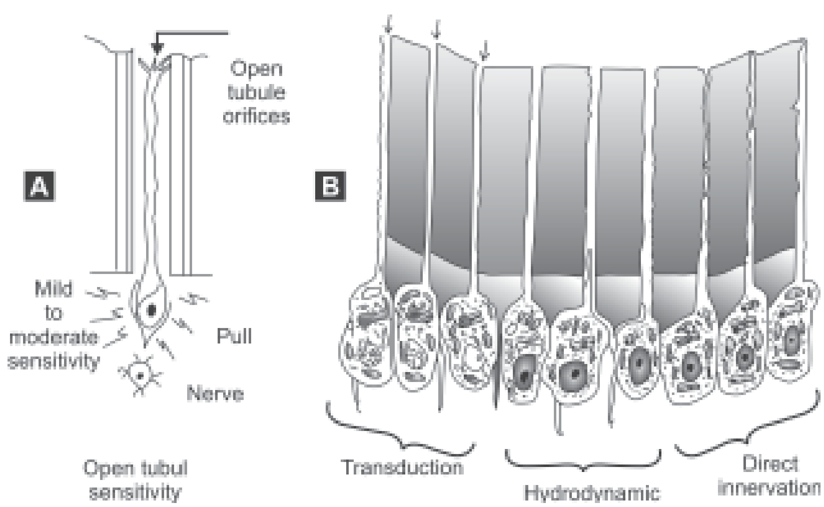
Pain Reaction

Process by which impulse is generated and this impulse is transmitted to the CNS.

Pain reaction: It represents the individual manifestation of unpleasant stimulus. It can vary from individual to individual.

Pain Reaction Threshold Factors

1. *Emotional status:* Emotionally unstable → low threshold



Figs 3.1A and B: Theory of sensitive

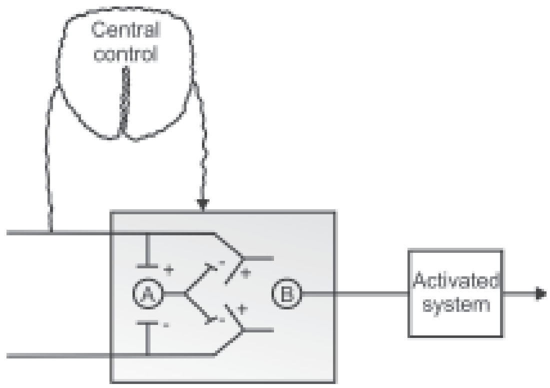


Fig. 3.2: Gate control theory

2. *Fatigue:* Tired patient → low threshold
3. *Age:* Older individuals → higher pain threshold
4. *Sex:* Male → Higher pain threshold

Control of Pain

Three phases:
1. Pain control before treatment
2. Pain control during treatment
3. Pain control after treatment

Find out the cause of pain and eliminate it.

Pulpal Pain

1. Deep caries
2. Thermal changes without protective base
3. High points in restoration
4. Traumatic injuries

   Treatment
   a. Deep caries excavation and use of cements
   b. Pulp capping procedures in deep cavities
   c. In case of deep cavities with amalgam restoration. So a protective base should be used for metal restoration.
   d. Articulating paper should be used to check reduce them.
   e. Attend to the traumatic injury and do the needful.
   f. Find the cause of referred pain and treat the cause.

During the Treatment

Use of high speed instrumentation with cavity preparation:

a. H_2O coolants which will decrease heat and pain.
b. Small bur size, as the size as bur increases heat dissipated increases.
   In continuous cutting – The heat generated is increased
c. Minimal pressure while cutting sharp instrument and speed.
d. Condensation pressure → 4-5 pounds if increase then this patient might complain of pain.
e. Burnishing and caving to be done after initial setting of material.
f. Polishing should be done in wet medium as it generates less heat and does not lead to pain.

After Operative Treatment: After 24 hrs

Causes:

a. High speed cutting without coolant
   Treatment– Remove restoration and place temporarily sedative dressing and wait till the pain stops and the proceed for permanent restoration.
b. *High points*
   Treatment– Reduce them.
c. Restorative material used → deep cavity restored with amalgam without base.
   Treatment– Remove the restoration and place base subase, varnish is needful.
d. If pain persists then do pharmacological treatment
   Treatment–
   – Analgesic
   – Anti-inflammatory agents

– Sedatives
– Anesthetics

LOCAL OR REGIONAL ANESTHESIA

Definition

A loss of pain sensation over a portion of anatomy without loss of consciousness.

Technique

a. Topical anesthesia
b. Local infiltration
c. Field block anesthesia
d. Nerve block
e. Intraligamentary
f. Crestal anesthetic technique (CAT)

Topical Anesthesia

Free nerve endings are anesthetized in accessible sites by application of suitable anesthetic agent directly on the surface, e.g. a gel.

- LA Spray
- Intact mucous membrane usually used and on abraded skin
- It is used in combination with other techniques.

Fig. 3.3: Local infiltration

Fig. 3.4: Field block

Local Infiltration (Fig. 3.3)

Small nerve endings in the area of surgery are floaded with LA to render them insensitive to pain.

Applied on area of surgery using a syringe.

Field Block (Fig. 3.4)

Depositing the anesthetic solution in proximity to larger terminal nerve branches so that area is anesthetized and efferent impulses are prevented.

Nerve Block (Fig. 3.5)

Depositing the anesthetic solution in close proximity to main nerve trunk so that area is anesthetized and efferent impulses are prevented, used commonly.

Intraligamentary Technique (Fig. 3.6)

The anesthetic solution is forced under pressure into periodontal ligament space of max and mand teeth.

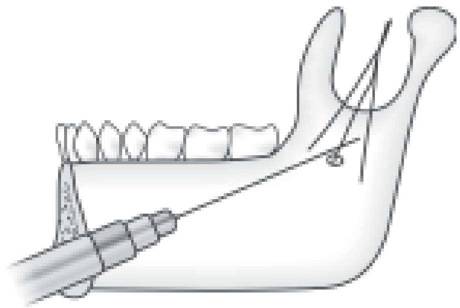


Fig. 3.5: Nerve block

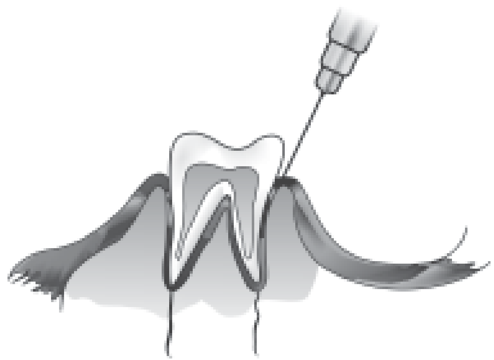


Fig. 3.6: Intraligamentary technique

Syringe is used but special which can bear the force.

CAT

I. Anesthetic solution is forced into the crestal bone.
II. Electronic anesthesia
III. Audio-analgesia
IV. Inhalation analgesia
V. Hypnosis
VI. Acupuncture

Electronic Anesthesia

Also called transcutaneous electronic nerve stimulation (TENS). Connecting used based upon the gate control theory.

Advantages

1. Unlike LA it is non-invasive
2. Safe
3. Well accepted by the patients
4. Easy to master and operate
5. No risk of allergy

Contraindications

1. Heart disease where in the pack makers are used.
2. Seizure disorders, i.e. epilepsy

Audio Analgesia

Also called white noise. It provide a sound stimulus of such intensity. So that patient will find it difficult to attend to anything else.

Principle: Stimulus distraction.

Soft music, e.g. Constant rainfall.

Inhalational Anesthesia

Also called as conscious sedation. Inhalation of $N_2O + O_2$ so it is supposed to give a sedative effect and cuphoric state of well being.

HYNOSIS

Definition

State of mind in which critical faulty of the mind has been bypassed and selective thinking is established.

Advantages

a. Total relaxation
b. Analgesia
c. Decrease gagging
d. Controls saliva
e. Controls hemorrhage
f. Controls fainting.

4A Brief Cavity Preparation

Cavity preparation is defined as the mechanical alteration of a defective, injured or diseased tooth in order to best receive a restorative material which will reestablish a healthy state for the tooth including esthetic corrections. Which indicated along with normal form and function.

Objectives of Cavity Preparation in General

1. Remove all defects and give the necessary protection to the pulp.
2. Locate the margins of the restoration as conservatively as possible.
3. From the cavity so that under the force of mastication the tooth or the restoration or both will not fracture and the restoration will not be displaced.
4. Allow for the esthetic and functional placement of a restorative material.

Stages and Steps in Cavity Preparation

Cavity preparation is categorized in two stages:

- Initial cavity preparation stage
- Final cavity preparation stage

Initial Cavity Preparation Stage

It consists of four steps:
Step 1: Outline form and initial depth
Step 2: Primary resistance form
Step 3: Primary retention form
Step 4: Convenience form.

Final Cavity Preparation Stage

It consists of 5 steps:

Step 5: Removal of any remaining enamel pit/fissures and/or infected dentin and/or old restorative material if indicated

Step 6: Pulp protection

Step 7: Secondary resistance and retention forms

Step 8: Procedure for finishing external walls

Step 9: Final procedures of cleaning inspecting, varnishing, conditioning.

Cavity Preparation Terminologies

Simple cavity preparation—if the preparation involves only one tooth surface, if two surfaces are involved it is termed compound cavity preparation. If there is more surface are involved the preparation in termed complex.

Internal wall is the prepared cavity surface that does not extend to the external tooth surface.

Axial wall is an internal wall parallel with the long axis of the tooth.

Pulpal wall is an internal wall that is both perpendicular to the long axis of the tooth and occlusal to the pulp.

External wall is prepared cavity surface that extends to the external tooth surface and such a wall takes the name of the tooth surface that the wall is toward.

A floor or seat is the prepared cavity wall which is reasonably flat and perpendicular to those occlusal force directed occluso-gingivally, e.g. pulpal floor, gingival seat.

Enamel wall is that portion of a prepared external wall consisting of enamel.

Dentinal wall is that portion of a prepared external wall consisting of dentin which may contain retentive features.

Line angle is the junction of two planal surface of different orientation along a line.

An internal angle is a line angle whose apex points into teeth.

An external angle is a line angle whose apex points away from the tooth.

Point angle is the junction of three planal surface of different orientation.

Cavosurface margin is the junction formed by the prepared cavity wall and external surface of the tooth.

The angle so formed in the cavosurface angle.

Factors Affecting Cavity Preparation

General Factors

Diagnosis: A thorough diagnosis is must before any restorative procedure, there must be a reason to place a restoration in the tooth.

The treatment of tooth, i.e. choice of material and design of cavity preparation depends on the pulpal and periodontal status of the tooth and also occlusal relationship.

Relationship with the other treatment procedure also influence the restorative treatment.

Esthetics of the patient is also considered.

Risk potential of the patient to further dental disease should also be considered.

Knowledge of dental anatomy is a prerequisite for understanding cavity preparation. The direction of enamel rods, thickness of enamel, the dentin, body size of pulp, position of pulp horns and relationship of the tooth to internal structure is to be known to judge cavity preparation accurately.

Patient Factors

a. Patient knowledge and appreciation of good dental health will influence the desire for restorative care and thereby the materials.
b. Economic status influence the type of restorative care selected.
c. Patients age should be considered for selecting the material and consequently the cavity preparation.

Conservation of Tooth Structure

a. Preservation of tooth vitality is of great importance in operative dentistry. The less the tooth structure removed the less will be insult to pulp.
b. Smaller the cavity better the retention of the material and also better inter-arch and interact relationship and esthetics.

Initial Cavity Preparation Stage

It is defined as the extension and initial design of the external walls of the preparation at a specified limited depth so as to provide access to the cavity or defect, reach sound tooth structure, resist fracture of the tooth or restorative material from masticatory forces. Principally directed with the long axis of the tooth and retain the restorative material in the tooth.

Steps in initial cavity preparation are:

Step-I: Outline Form and Initial Depth (Fig. 4A.1)

Establishing the outline form means 1. Placing the cavity margins in the positions they will occupy in the final preparation except for finishing enamel wall and margin.

Except for finishing enamel walls and margins and preparing an initial depth of 0.2 to 0.8 mm pulpally of the dentine enamel junction portion or normal root surface portion.

Principle on which Outline Form is Established

1. All friable and/or weakened enamel should be removed.
2. All faults should be included.
3. All margins should be placed in portion to afford good finishing of the margins of the restoration.

Factors that Affect Cavity Preparation Outline Form

1. Extend or caries lesion, decayed or faulty old restoration.
2. Esthetic consideration
3. Occlusal relationship
4. Adjacent tooth contour
5. Cavosurface margin configuration of the proposed restoration.

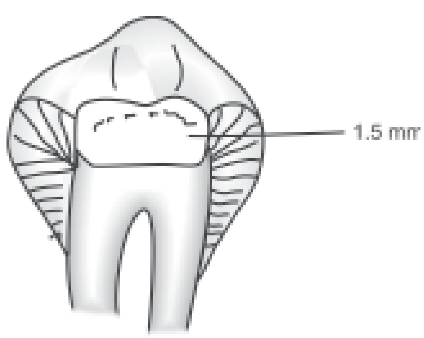


Fig. 4A.1: Initial cavity

Features of Outline Form and Initial Depth

1. Preserving cuspal strength
2. Preserving marginal ridge strength
3. Minimizing faciolingual extensions
4. Using enameloplasty
5. Connecting two close faults or cavity preparation that are less than 0.5 mm apart
6. Restricting the depth of the preparation into dentin to a maximum 0.2 mm for pit and fissure caries, 0.2 to 0.8 mm for the axial wall smooth surface caries.

Rules to be followed in Establishing Outline Form for Pit and Fissure Cavities

1. Extend the cavity margins until sound tooth structure is obtained and no unsupported or weakened enamel remains. Do not terminate the margin at cusp heights or ridge crest. By the extreme from the primary groove is more than decay of the cusp include cusp capping can be done.
2. Extend the cavity margin to include all the fissure that cannot be eliminated by enameloplasty.
3. Restrict the depth of the preparation to 0.2 mm in dentine
4. Join two pit and fissure which is only separated by 0.5 mm or less of sound tooth structure to eliminate weak enamel wall between them.
5. The outline form should preserve as much cusp incline as possible.

Rules for Establishing Outline Form for Proximal Surface Cavities

1. Extend the cavity margins until sound tooth structure is obtained and unsupported and/or weak enamel remains.
2. Avoid terminating the margins on cusp heights or ridge crest.
3. Extend the margins to alloy sufficient access for proper manipulation procedures.
4. Extend the margins to allow sufficient access for proper manipulation procedures.
5. Restrict the axial wall depth of proximal preparation to a maximum of 0.2–0.8 mm into dentin.
6. Extend general margins of cavity apically to contact to provide maximum clearance of 0.5 mm between general margins and adjacent tooth.

Extend the facial and lingual margins in proximal cavity preparation into the respective embrasures to provide clearance between the margins and adjacent tooth.

1. When extending the proximal surface mesially in class III preparation it is acceptable to portion the initial margin in the area of contact.

Conditions that may warrant consideration of restricted or reduced extension for smooth surface cavity preparation are:
- Proximal contour and root proximity
- Esthetic requirements
- The use of modified cavity preparation for composites

Increased extension for smooth surface cavity preparation is needed on:
- Advanced age of the patient
- Mentally a physically handicapped
- Restoration of teeth that is to act as abutment for partial dentine.
- Restoration of teeth that is to act as unit of a splint.
- Need for additional retention and resistance form.
- Need to adjust both contour.

Step-2: Primary Resistance Form (Figs 4A.2 and 4A.3)

It is defined as that shape and placement of the cavity wall that best enable both the restoration and the tooth to withstand without fracture masticatory forces delivered principally along the long axis of the tooth.

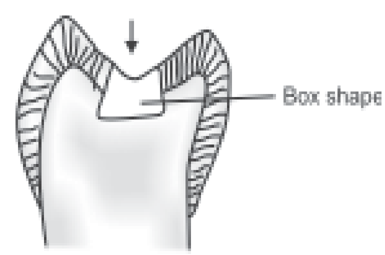


Fig. 4A.2: Primary resistance form (correct)

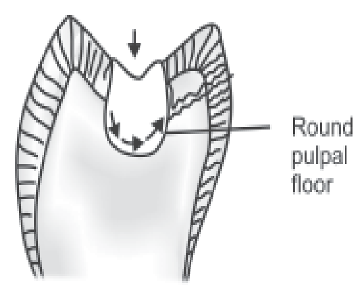


Fig. 4A.3: Incorrect resistance form

This is provided basically by relatively flat pulpal floor and flat gingival seat.

Principles

1. To utilize the box shape with a relatively flat floor which helps the tooth to resist occlusal loading, as they are right angled to masticatory forces.
2. To restrict extension to allow strong cusp and ridge areas to remain with dentin support.
3. Rounding of internal line angles slightly to reduce stress concentration in tooth structure.
4. To cap cusp and envelops enough of weakened tooth within the restoration in extreme cavity preparation.
5. To provide adequate thickness of the restoration materials to prevent fracture under load.

Factors that Affect Primary Resistance Form

- Occlusal contact by occlusal load is great, potents for fracture
- Amount of remaining tooth structure
- Type of restoration material.

Design Features and Cavity Preparation that Enhance Primary Resistance Form

1. Relatively flat floor
2. Box shape
3. Inclusion of weakened tooth structure
4. Preservation of cusp and marginal ridges
5. Rounded internal line angle
6. Adequate thickness of restoration material
7. Reduction of cusps for cusp capping when indicated
8. Seats on sound dentin peripheral to infected dentin excavation.

Step-3: Primary Retention Form (Figs 4A.4 to 4A.8)

It is defined as that shape or form of the prepared cavity that resist displacement or removal of the restoration from tipping or lifting forces.

Principles

1. For amalgam, class I and class II preparation the material is retained by developing external cavity walls that converge occlusally.
2. For amalgam class III and class V retention caries and grooves are prepared in the enamel walls to provide retention.
3. Adhesive system provide some retention by micromechanical bonding of amalgam to teeth structure.
4. Conditioned, prepared tooth surface provides scope for mechanical bonding of composite restoration to tooth structure then providing retention.
5. Parallel vertical walls provide retention for intracoronal restoration small angle of divergence from the line of draw will enhance retention to casting in tooth structure.
6. Occlusal dovetail provide retention in prooximocclusal preparation (class II).

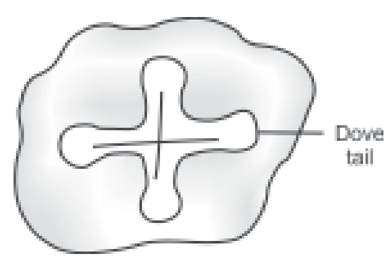


Fig. 4A.4: Primary retention form

Step-4: Convenience Form

It is defined as the shape or form of the cavity that provides for adequate observation, accessibility and ease of operation in preparing and restoring the cavity.

Final Cavity Preparation Stage

Step-5

Removal of any remaining enamel pit or fissure and infected dentin or old restorative material if indicated.

It is the elimination of any infected carious tooth structure a faulty restorative material left in the tooth after initial cavity preparation.

The affected dentin is allowed to remain in prepared tooth but infected dentin is removed.

Old restorative material should be removed if there is:

- Chance of color change of new material which affects the esthetic.
- If the old material compromises the anticipated amount of retention.
- Radiographic evidence of caries under it.
- Tooth pulp is symptomatic preoperatively.
- Periphery not intact.

Caries remaining is excavated by spoon excavation or round steel bur. Restorative material like amalgam can be removed very round carbide bur with air water coolant.

Step-6: Pulp Protection (Fig. 4A.5)

- Heat generated by injudicious cutting
- Some ingredients of dental materials
- Thermal change transmitted through the restorative material
- Forces transmitted through the material to dentin
- Galvanic shock
- Ingress of toxic products and bacteria through microleakage.

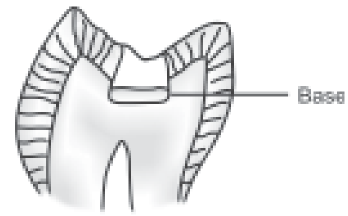


Fig. 4A.5: Pulp protection (One type of base)

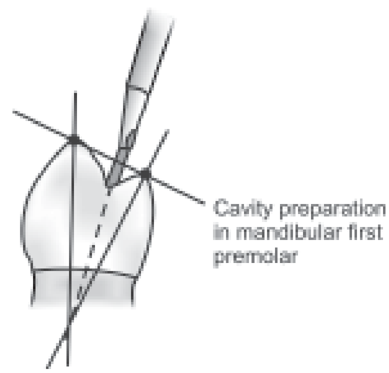


Fig. 4A.6: Cavity preparation in first premolar (Mandibular)

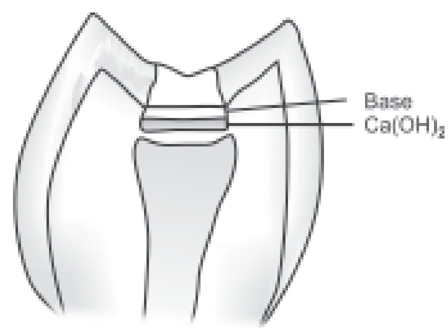


Fig. 4A.7: Pulp protection (In deep carious)

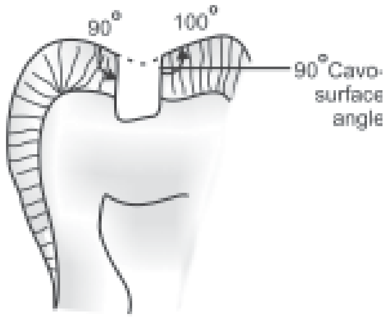


Fig. 4A.8: 90° cavosurface angle

Liner/Bases/Varnishes are Needed for Various Purpose

If the excavation extends into or very close to the pulpal, calcium hydroxide liner is used to stimulate reparative dentin formation.

If the removal of infected dentin does not extend deeper than 1 mm from the initially prepared pulpal floor or axial wall no liner is indicated.

If the excavation is between these 2 condition zinc oxide eugeonol liner is used. To provide a palliative, sedative pulpal response.

Thus, liner and looses in exposure area should be applied without pressure.

Do not use liner or base for components restaction except when the excavation or 0.5 mm or less to the pulp.

Two coats of varnish applied later prevent microleakage as well as penetration of material into dentin. So reduces postoperative sensitivity.

Step-7: Secondary Resistance and Retention Form

This is required for many compound and complex cavity preparation.

Many preparation features that improve retention form will also improve resistance form.

This secondary resistance and retention forms can be of two types:
1. Mechanical features
2. Cavity wall conditioning features

Mechanical Features

- Retention locks
- Retention grooves
- Retention coves

Groove extensions—Molars—extending cavity preparation surface, arbitrarily to include facial or lingual groove.

Skirts—cast gold restoration.

Beveled enamel margins—for cast gold restoration and composites.

Pin slots, steps and amalgam pins.

Cavity Wall Conditioning Features

Acid etching of enamel—porcelain, composites, amalgam and glass isomer restoration.

Dentin conditioning—bonded porcelain, composites amalgam and GIC restorations.

Step 8: Procedure for Finishing the Extension Wall of the Cavity

Preparations

It is defined as further, development when indicated of a specific cavosurface design and degree of smoother that produces maximum effectiveness of the restorative material being used.

The objective of furnishing the cavity walls are:
1. Creates a best marginal seal between the material and tooth structure.
2. Affords a smooth marginal function.
3. Provides maximum strength for both the tooth and restorative marginal and near the margins.

Factors to be Considered in Finishing Enamel Walls and Margins

- Direction of the enamel rods
- Support of the enamel rods
- Type of material to be placed in the preparation
- Location of the margin
- Degree of smoothness desired.

Features

There are 2 primary features related to finishing external walls:
1. Design of the cavosurface angle
2. Degree of smoothness of the wall

Design of the cavosurface angle depends on the restorative material to be used.

The cavosurface angle for amalgam is 90 degree to provide maximum strength both amalgam and tooth (Amalgam has low edge strength).

For intracoronal cast gold/metal restoration and composite restorations external wall is beveled.

Bevel for cast restoration serves 4 functions:
1. Produces a stronger enamel margin
2. Provides marginal seal for slightly undersized casting
3. Marginal metal can be easily burnished and adapted
4. Assist adaptation of gingival margins to casting

   For casting the bevel is 30-40 degree.

For composites, beveling increases the surface area of enamel for acid itching so better retention also minor defects can be included in the bevel and esthetic is enhanced by gradual decrease in composite thickness from the bulk of restoration to margins.

Step-9: Final Procedure Cleaning, Inspecting, Varnishing and Conditioning

Cleaning includes removal of all chips and loose debris that have accumulated—warm water in a syringe is used for this purpose.

Inspecting—dry the cavity without desiccating it and inspect the cavity for any remaining infected dentin, unsound enamel margins present any other irregularities.

If recommended use 2 coats of varnish.

If the material to be used is composites, conditioning of the cavity preparation is done prior to material insertions. Conditioning is also used for amalgam restoration and GIC restoration.

This conditioning can be acid etching of enamel, application of dentin bonding agent, or application of glass ionomer liner.

Moisture control refers to excluding salivary fluid, saliva and gingival bleeding from the operating field.

4 Biomechanics of Cavity Preparation

INTRODUCTION

Cavity preparation is the mechanical alternation of tooth to receive a restorative material which will return the tooth and axis to proper form, function and esthetics in harmony with health of surrounding tissues.

The restoration basically replaces the lost tooth structure and is subjected to similar variety of forces and load as were falling on intact tooth. These forces may be generated during mastication, swallowing, speech, clinching, bruxism and also by the action of tongue and perioral and circumoral musculature.

So a stress becoming, biologically compatible replacement of tooth structure is required. Till date there is no such restorative material having properties similar to enamel and dentine so the dentists have to work within the limits for present day restorative materials. So the cavities should be designed in such a way so as to protect the remaining tooth structure from further destruction and also to increase the longevity of the restoration.

To design such a mechanically and biologically acceptable cavity, the knowledge of certain engineering principles and biomechanics is important. This chapters is an attempt to highlight some of the basic principles of mechanics and its applications in cavity preparation. Also we will be discussing certain biological considerations during cavity preparation.

What is Mechanics?

According to Webster mechanics is that science or branch of mathematics which deals with the action of forces in bodies.

What is Biomechanics?

Simply it means application of mechanics to biologic systems.

The interactions between the applied forces, the shape and structure of the teeth, the supporting structures and the mechanical properties of tooth components and restorations.

Biomechanics is the study of loads and deformations occurring in biological systems.

The main contribution in the study of mechanical principles and its application in operative dentistry is by Dr. Arthur B, Gobel.

MANDIBLE AS A LEVER

The mandible acts as a curved movable for that moves against the fixed superior skull. It is designed like other stress bearing bones and is modified by function to resist oral forces. Much of this adaptation is internal as seen by presence of medullary trabeculae.

Which form stress distributing channels between alveolar bone and cortical plates.

The human jaws has been described in terms of lever systems. Force couples, and stationary become. The current tromechanical model describes mandible as class III lever. In this analogy, the condyle is the fulerum. The combined force of elevating muscles is the applied force, and the bite force is the resistance force. As the applied forces the between the fulerum and the resisting force, it belongs to lever of third class with a mechanical advantage of less than one.

This lever system requires that the resistance force be less than the applied force to achieve equilibrium. As the bite force is moved anteriorly, the mechanical advantage decreases and with increased muscle force is needed to maintain equilibrium or to do work because the moment arm is increased.

ANALYSIS OF THE FORCES ON THE TOOTH

The tooth is the immediate agent through which the work of masticating the food is accomplished. The forces required to bring about the communication of food are applied through the bone of the mandible and the periodontal membrane to the root of the tooth. These forces in turn are determined by the reacting forces of the tooth itself. The reaction of the tooth in its turn is determined not only by the magnitude of the forces exerted but by nature of surfaces in contact. If the occlusal and incisal surfaces of the teeth were flat and at right angles to the direction of the forces applied, the reaction of the tooth would be along its long axis. However, the opposing surfaces are curved so that other forces are set up and the applied and reacting forces are not along the long axis of the teeth.

When a force acts perpendicularly to a fixed horizontal frictionless surface, the surface reacts at right angles to its plane with an equal and opposite force. If the surface is now tilted at an angle to horizontal, it still reacts at right angles to its plane as this is the only direction in which frictionless surface can react. Its reacting force therefore no longer opposes the applied force in direction nor is it equal to it in magnitude, hence the forces are not in equilibrium.

COMPOSITION AND RESOLUTION OF FORCES

A force has both magnitude and direction. It can be resolved into a number of component forces usually two at right angles to each other, e.g. an oblique force, R in the plane of paper can be resolved into a vertical component Y, and a horizontal component X. The component forces may also be drawn head end as to tail end. The representing the forces will be a triangle with the component forces forming the two sides and the original force the third side. It can be seen that by reversing this process, forces can be added, e.g. considering the two component forces, Y and X as the original forces, the resultant R can be obtained by drawing them end to end and joining the free ends. This line represents the resultant force in magnitude and direction.

If forces are in equilibrium with the resisting forces of the surface, such a force can represented by reversing the direction of resultant. The figure is a triangle with the forces end to end all pointing around the triangle in the same direction.

Inclined Plane

It is now possible to consider the forces acting at the points of contact between two cusps.

If X represents the angle made with the horizontal by the tangent to the cusp at the point of contact and the arrow M, represents the masticatory force at the same point in case there is no friction, the reacting force is perpendicular to the tangent at the point of contact and of such length that when projected on the vertical force, M, its projection is equal to M. The projection of normal force is N and its vertical H is equal and opposite to force of mastication H is the horizontal component which must be balanced by an opposing lateral force.

Also as the angle of incline (a) decreases or as the incline approaches the horizontal N becomes shorter and finally is equal to M and H to reduce to zero. If a increases N and H also increases.

Effect of Friction

Friction is the resistance to a sliding motion of one body over another. It plays an important part in determining forces acting in a tooth because of lubricating value of saliva and food.

In this between the normal N and the force of mastication M, which is vertical at the point of contact a line at an angle to the normal equal to the angle of friction, p, is drawn and prolonged. This represents the true direction of force of reaction, of the inclined plane. Its magnitude is determined by drawing it long enough so that its projection on the line representing the force of mastication is equal and opposite to the force of mastication as in the frictionless cover. The line representing the horizontal force is then drawn forming the ends of M and R.

We can see that as angle of friction b increases, the reacting force of the plane decreases and also the horizontal force exerted by the cusps.

It is also evident that when the angle of friction is equal to the angle of slope of cusps (a), the reacting force of opposing tooth is equal and opposite to the force of mastication and horizontal force is zero. In other words in case of teeth whose cuspal inclinations have been reduced to where they are equal to angle of friction between two surface, the forces of reaction are the same as though the two surfaces were at right angles to force of mastication.

Wedging

Frequently points of contact in two or more inclined surfaces with slopes facing each other involved, as in the case of cusp of tooth contacting the buccal and lingual cusp of the opposing tooth or the buccal and lingual cusp and the mesial marginal ridge. It is this condition which accounts for the displacement of restorations or fracturing of teeth. The effect produced is that of a wedge and can be explained by assuming two inclines sloping together as in the Figure 4.5 and considering the force applied to the base of each as half of force of mastication.

The horizontal components of the normal force set up by the inclines are equal and opposite and tend to push the inclined surfaces apart. The horizontal or wedging force is therefore the same as that of one incline with half the applied force. In other words, the horizontal wedging force is half the lateral force in the case of one incline only. Each horizontal component is reduced by friction in the same manner as described for the single inclined plane.

FORCES ACTING ON THE TOOTH

To consider the effect of all the forces acting on the occlusal surface of a tooth during mastication, the teeth should be intimate contact or when separated by a compressed, relatively thin layer of resistant food.

The teeth are in centric occlusion under a pure closing effect. Only axial forces are applied to the tooth. Rab is resultant of pieces a and b. To meet the condition of equilibrium Hab should be equal to HC. Then Vabc is only force acting on the tooth.

In chewing, the mandible moves from lateral to centric occlusion under forces whose resultant is not vertical but inclined medially. This has the effect, when tough funds are compressed or all cusps are in intimate contact at the three points, and decreasing the forces a and b and increasing with corresponding changes in their horizontal and vertical components. The resultant RABC is a thrust inclined lingually on the maxillary or buccally on the mandibular teeth whose horizontal component is Habc.

Teeth are in lateral relationship or “working bite” with no food or a very thin layer between there opposing surfaces. In the disease of force c. There is no horizontal component to balance Hab.

A force C may be produced by a thin compressed layer of food tough enough to offer resistance to bringing the buccal slope of lingual cusp of maxillary tooth into contact with the lingual slope of buccal cusp of lower as in fig d thus approximations a condition of axial loading.

Thus, we see that whole chewing cycle is complicated and even in normal occlusion the horizontal thrust may vary from buccal to lingual. When tipping or rotation alter the occlusal relationship. This picture may be completely changed depending on the nature of alternation.

MECHANICAL FUNCTION OF THE MARGINAL RIDGE

The wedging action of some foods particularly tough fibrous ones may cause separation of teeth with resultant packing between the contact points in spite of good contour and contact.

Assuming that the forces normal to the inclined surfaces are produced by biting on a bolus of tough meat. The horizontal component of normal forces a, b, c and d acting on tooth number i.e. and f actions on (2) and m,n,o and p acting on (3) in a cancel out. The horizontal components of g and k push (2) and (3) apart. h has no horizontal component.

This imbalance of horizontal components will not disappear completely until there is a ridge at the point of application of h of such slope and height that the horizontal component of h will cancel that of g and the surface of (3) on which k acts to shelded from the pressure of the bolus.

If the ridges meet the above requirement but not make contact near their crest, the teeth may be separated by the wedging action of the food as seen b, in which horizontal components of forces a, b, c, d, m, n, o and p cancel but those h and g force the teeth apart.

Thus, the height and slope of marginal ridges and restorations should be adjusted to correspond to natural cusps and ridges restorations in teeth the cusps are ridges of which have been work flat require no marginal ridges.

RESTORATION BEAMS

We know that materials with higher modulus of elasticity supports the greater part of the load. Some of the materials in use today have modulus of elasticity several times that of tooth structure, the occlusal step of class II restoration is not fully supported by the pulpal floor of the cavity and consequently behaves like a beam.

The proximocclusal restoration may be thought of as a cantilever beam and proximo-occluso-proximal as a beam restrained at both ends.

The cavilitever beam has a bending movement at the point of support equal to the load P times the length L. This moment is transmitted to the embedded portion of the beam which in the proximoocclusal restoration is its proximal part. So a gingival retentive force equal to R=PL/l is surface to the gingival floor.

In MOD restorations with the load applied at its mid-point, the end moments are PL/8. The gingival retentive force R should be PL/8L.

This both MO or DO or MOD the bending stresses are at the axiopulpal line angles due to the rectiamt of gingival locks.

Strength of Beam

It is directly proportional to width and directly proportional to the square of depth. Double the width, double the strength but double the depth, quodruple the strength.

Deflection of Beam

Deflection of beam increases directly as cube of the length (L) and inversely as width (H) and inversely on cube of its depth (H).

$$D = \frac{L^3}{bh^3}$$

It is inversely proportional to modulus of elasticity. Thus, differ material will deflect less.

APPLICATION OF MECHANICAL PRINCIPLE IN CAVITY PREPARATION

Class I Restoration

It is the simplest of those classes of restorations subjected to heavy masticatory loading. The entire restoration is enclosed in tooth structure except the occlusal surface. The side walls are usually parallel except in the case of inlay where there is a slight divergence. The floor is flat.

For amalgam moisture dropped preparation with parallel walls is best suited to withstand mechanical stresses. One of the variation that had been recommended particularly for amalgam is to converge the side walls including the enamel walls and also to slope the floor pulp towards the center. This type of cavity preparation removes more tooth structure at the center of the dentine bridge over the pulp. This bridge to weaker and less rigid at the point where the bending stresses are greatest. The side walls tend no support against occlusal loading as in the case of parallel or diverging walls thus taking none of the load fro the pulpal floor.

Because of this increased deflection there would be a marginal fantime particularly in young dentine where pulp chamber is large.

Upon excavation of decay a rounded pulpal floor remains and problem can arise.

If the occlusal loading is applied centrically there is disadvantage of an increase in unit normal stress in the deepest part of the cavity. This can be understood by considering a cylindrical cavity with a hemispherical base of the same radius. Around the periphery at the union of hemispherical and cylindrical portions, then is zero stress. From this point to deepest part of cavity, the unit stress increase continuously to a maximum. This maximum unit stress is twice the unit stress for a cylindrical restoration of same size and with flat base. The parallel walls gives some support to the restoration within the limit of the shear strength of the material. However if the strength is exceeded, a moderately great deflection is produced and restoration will joint.

A restoration with a rounded base when loaded eccentrically tends to rotate as a result of moment produced by applied force end eccentrically. This rotation is prevented by the side wall of the cavity which exerts as horizontal force, H, opposing it. There is an opposing horizontal force, H, near the base of restoration resisting the force H in the same manner that P acting on base opposes the masticatory load P.

Tendency of restoration with rounded floor to rotate can predispose to marginal leakage and even fracture of marginal tooth structure.

This is particularly in ease of shallow cavity as stress varies inversely proportion to square of depth.

The solution to this problem is to extend the cavity horizontally and creating a flat floor at ideal depth of 1.5 mm at three points at least. In case of inlay which is considered more region them tooth structure, if it is loaded eccentrically, if produces tensile stresses which will cause the inlay to separate from tooth if the eccentricity of load exceeds a particular value. The solubility can be increased by increasing the depth of cavity.

Class I restoration seldom fractures. It can only fracture under a heavy concentrated load if the restoration does not have sufficient thickness.

As stresses alpha = r/d^2, it follows that for larger restoration depth should be increased to have sufficient strength.

Class II Restorations

Problems with Class II Restoration

1. When class II restorations are restored with material with modulus of elasticity higher than tooth structure, it receives little support from underlying dentin and hence behaves like a beam.
2. Because of generation of end moments there is tendency of the restoration to rotate around gingiva axial line.
3. Under occlusal loading bending stresses are generated which are maximum at the axio pulpal line angles.
4. Another problem is that of wedging action which may be produced by opposing cusps contacting transverse and marginal ridge or cusps and marginal ridges. When this wedging action takes place in such a way that one point of contact is on a procimio-occlusal restoration while the other on tooth, there is tendency to wedge the two apart with a rotation about the gingival cavosurface angle.
5. When the cusp of tooth contacts the marginal riges of tooth, tensile stresses at generated at the marginal ridges.

Design Features of Class II Which Aids in Resistance and Retention Form in Amalgam

a. Occlusal dovetant: It is required for additional retention. It prevents the rotation about the gingival cavosurface angle due to wedging action.
b. Incorporation of grooves in the design: To prevent proximal displacement of entire restoration and prevent rotation of proximal portion self-retaining facial, lingual and gingival grooves are given in addition to occlusal done tait.
c. Convergence of faceproximal and linguo-proximal wall not come out until it fracture.

d. All other relevant feature of occlusal dovetail are similar to class I preparation.

Axiopulpal Line Angle

As the maximum bending stresses in class II restoration occur around, the axiopulpal line angle, the line angle, should be well rounded for additional strength at the point.

Another modification suggested by stanting the axial wall toward the pulpal floor. This increases the amalgam bulk near the marginal ridges, while bringing the axiopulpal line angle away from others concentration area and closer to the surface thereby reducing tensile stresses per unit area.

Width of isthmus should be ¼ the inter-cuspal distance as tooth resistance to fracture decreases with increasing width.

Depth of cavity should be 1.5 mm minimum so as to resist compressive forces adequately.

Cavosurface line angle should be at 90 degree as front feather edges marginal amalgam fractures under occlusal loading.

All line angles and point angles should be rounded to minimize stress concentration per unit area.

Reverse Curve

When the facial and lingual margins or walls on the occlusal surface approach the proximal surface. They should be prepared so as to meet the proximal surface at right angles.

Furthermore these walls should terminate past the contact area in corresponding facial and lingual embrasures.

In case of broad contact areas. The normal sweeping curves of occlusal outline and to begins of proximal margins into respective embrasure will require unnecessary removal of sound tooth structure thus weakening the remaining tooth structure.

To solve this problem the normal direction of sweeping curves of outline in the occlusal portion of proximocclusal preparation is reversed. This reverse curve is almost always necessitated on the facio-proximal aspect.

It preserves the tooth structure at the critical marginal area and places margins in cleansable area and terminates margins in right angle cavosurface.

Proper Carving of Marginal Ridge Anatomy should be done in Case of Cost Metal Restoration as General Feature of Resistance and Retention

a. Preparation path: There should be single path of insertion parallel to long axis of the tooth crown.
b. Apico-oclusal taper of preparation: For maximum retention, opposing walls should be parallel to each other. But this parallelism creates problem in removal of pattern. So slight divergence of opposing walls is given. This taper should be 2-5^{o}.

   Greater the length of wall greater and taken but if more retention is required, then taper is decreased to approach parallelism.
c. Occlusal Dovetail is given for retention.
d. Circumferential tie: The weakest link in and cast restoration is the tooth/cement/ cost found complex. So every effect should be made to design and prepare these marginal periphery to create the most favorable relationship with restering casting luting cement. This perpheial marginal anatomy of preparation is called "circumferential tie". This includes gingival level, primary and secondary flare and occlusal level.

e. Grooves extending from the cervical floor to the occlusal surface are sometimes place in the dentine portion of the proximal walls to prevent lateral dislodgement of restoration.

Need for Gingival Lock

As the cast gold restoration have modulus of elasticity more than that of dentine, so there is tendency of rotation of restoration around gingivoaxial line angle.

This represents a proximo-occlusal restoration. For the sake of simplicity, the shape and dimension of gold cememnt dentine perpndicular parts are same when a uniprimly distributed load 2 P is applied, the dentine prism of height h is stressed less because of its love modulus of elasticity than the corresponding gold prism. So that whole gold structure tends to rotate counter clockwise.

So a gingival lock is required to prevent this rotation which by exerting the retent force and combined with the resistance R′ of axial wall produces the couple which cancel the force tending to rotate the restoration.

Reverse Level

It is placed at the expense of the gingival floor creating an internal dentinal plane inclining gingivally axially, locking the restorate and preventing proximal displacement. It always has a flat dentinal transition between it and the proximal gingival level. It can only be used when the gingival floor has sufficient dimensions to accommodate it without decreasing the resistance form of the restoration.

So for the restoration to be displaced, it has to be raised above the flat portion of gingival floor.

Additional retention is provided by giving internal bokes pins and slots.

Frictional retention: It is provided by friction between the cement and the walls of cavity.

Proper carving and restoration of marginal ridge anatomy should be done.

Class IV Restoration

Of the proximal restoration of the anterior teeth we will consider only class IV restoration as class III is normally inaffected by masticatory forces.

Forces Acting on Anterior Teeth

For any proximal restoration in anterior teeth there are two possible displacing forces.

a. Horizontal component of force displacing or rotating the restoration in a labio-proximo-lingual or linguo-proximo labial direction. It has its futerum almost parallel to the long axis of the tooth being loaded.
b. Second is vertical component of force displacing or rotating the restoration proximally and having a fulerum at the gingival margin of the preparation. So in anterior teeth with normal overbite and overjet during centric closure mainly horizontal forces will be active. This will try to move the restoration linguo-proxima labially in upper teeth and labio proxima, lingually in lower teeth. But the magnitude of horizontal force is not very substantial.

In case of angles class III, the forces will be same but the rotation or displacement will be labio-proximal lingually for uppers and linguo-proximolabially for lowers.

In occlusion with deep anterior overbite and normal or no overjet, the horizontal type of loading will be greatly exaggerated.

Mechanical problems at the distal of cuspid

It is an area of substantial stress concentration. It is one of the few areas in the mouth where three types of stresses, i.e. compression, shear and tensile are present substantially. This is because

a. The anterior component of forces concentrates at the function between the anterior segment and premolar region. Cuspid stands at this junction.
b. In normal excussion mechanism, the cuspid will be the last to disocclude so it caries the maximum occlusal load for longest period of time.

Because of wide lingual embrasure or distal of cuspid and labial location of contact area, the forces will try to tip the restoration lingual portion distolingually.

Therefore, additional retentive feature have to be given like:

(i) Having bulkiest walls possible.
(ii) Retention placed in every safe area cavity, i.e. along line angles point angles.
(iii) Incorporation of lingual locks or incisal retention in the cavity design.

Class V Restoration

Class V restorations confined to one surface and not subjected to direct loading may be though of as free of any mechanical problems. However as the mandible moves in lateral excussion, the lingual slopes of the buccal and lingual cusps of axillary teeth load the buccal slopes of the buccal and lingual cusps of mandibular teeth.

We have facial class V restoration in the lower molar tool. As the tooth is family seated in the bone, the tooth structure of the crown can move from position 1 to 2 of making a V-shaped opening at the margin together with facial component of the force driving the restoration facially.

Although this opening and the facial component of force are very minute and may not displace the restoration completely their repetition thousands of times per day can create marginal failures and eventually result in facial pratrusion of the restoration.

The same thing can happen in case of a lingual restoration in lower teeth and a facial or lingual one in upper teeth. The amount of force as well as dimensions of this V-shaped space are increased with increasing.

a. Steepness of cusp
b. Width
c. Depth of preparation
d. Length of clinical crown
e. Occluso-apical taper of tooth
f. Less bulk of tooth at the level of cavity preparation
g. Frequency of lateral excursion forces

To determine the effect following retentive features are given.

a. Placing grooves doing the gingiva axial or occlusoaxial line angles in case of amalgam.
b. In case of cast metal restoration provision of additional retention is by income of pine.
c. Definite line angles and point angles.

Biologic Considerations During Cavity Preparation

Cavity preparation introduce a number of irritating factors to the pulp and the periodontium.

Irritating Factors to the Pulp

1. The actual cutting of dentine can irritate as much as 30000-75000/mm^3 of odontoblasts.
2. Pressure of instrumentation whether by hand or rotary instruments causes the aspiration of the nuclei of the odontoblasts or the entire odontoblasts. This can lead to their complete degeneration and disintegration. Moreover, core should be taken during instrumentation at depths approaching the pulp as the pressure may drive some micro-organisms from infected cavity floor into pulp.
3. Condition at type of cutting instrument: Sharp hand cutting instruments do the actual cutting instead of crushing the vital dental tissues and are most biologically acceptable cutting instruments. Rotary instruments crush the vital dentine much more than other cutting instruments.
4. Thermal injury: "Cooling the pulp in its own juice" is how bodecker described tooth preparation without proper coolant.

Cutting of dentine with a rotating bur or stone produces a considerable amount of frictional head. The amount of heat produced is determined by speed of rotation, size and shape of cutting instrument, length of time the instrument is in contact with the dentine is the amount of presence exertion on the handpiece.

So in if high temperature are produced in deep cavities by continuous cutting without proper cooling, the underlying pulp may be severely damaged. If the damage is extensive and the cell rich zone of the pulp is destroyed, reparative dentine may not form.

Remaining dentine thickness also plays a role in determining the pulp response to thermal injury. As the thermal conductivity of dentine is relatively low, heat generated during the cutting of a shallow cavity preparation is much less likely to injure the pulp than deep cavity preparation. The greater political for damage to pulp was cutting dentine within a radium of 1-2 mm.

Speed of Rotation

A speed of 6000-70000 RPM was found by investigators to be most determinant if adequate water coolant to used. Ultra speed with proper coolant was found to be less traumatic because of less force required to do the cutting.

Nyborzy and Bromstrom investigated the effect of heat on the pulp of anesthelized for extraction. They applied a constant heat of 150°C for 30 sec on teeth whose remaining dentine thickness was less than 0.5 ml.

After extraction histological analyses showed disappearance of cell rich zone. It generalism cellular degeneration and localized absences.

Brushing of teeth during cavity preparation to attributed to frictional head. This pinkish time represents vascular stain in the sub-odontoblastic capillary plexus blood flow.

To Avoid This Injury

a. Minimum force should be applied during cutting
b. Size of cutting tool should be decreased
c. Use of coolants should be more mandatory particularly in high speed plain water is most effective coolant of choice. Next cement the cemenadtion of air and water. Air alone does more harm than good.

To be effective, the water should be delivered directly at the point of contact between the rotary cutting head and tooth.

In case of high speed, an area of turbulence is created which tends to deflect the water from the dentine being prepared so a fet of water with sufficient power and velocity to required to penetrate this turbulence.

Desiccation of dentine if occurring to the extent that some water from protoplasm of tonic, fibics is eluminated will cause disturbance in the ormotic pressure of dentinal tubules resulting in aspiration of nuclear of odontoblasts or odontoblasts. It involves bonding to its degeneration so tooth must be kept in a family sterile hydrous field during preparation.

Vibrations

Which are measured by their amplitude or their capacity and frequency are an indication of eccentricity in rotary instruments. The higher the amplitude, more destructive is the response of the pulp.

Besides affecting pulp tissues, vibrations can create microcracks in enamel and some non-elastic dentine. These cracks may propagate and interconnect directly forming the oral environment with delicate pulp and periodontal tissues. They increase the permeability of dentine and enamel to oral diffusants.

More extensive the preparation more is the damage to underlying dentine and pulp.

Pulp exposure: Exposure of the pulp during cavity preparation occurs most often in the process of remaining corrosions dentine. Accidental mechanical exposure may result during placement of pins – retentive point in dentine so anatomy of pulpal extension and age of tooth should been taken into consideration vatile giving additional retention.

Agents for cavity cleansing drying and sterilization also evoke pulpal response.

For cavity cleansing acid or chelations agent was used. This was found to increase pulpal inflammation significantly as shown in a study by cotton – Siegel (1778).

Drying agents generally contain organo-solvents such as either and acetone. Solvents containing drying agents should not be used in very deep cavities, since these agents are capable of damaging odontoblasts processes and cells of pulp.

In shallow and moderate deep cavities, they produce no significant pulp inflammation but because of desiccation cause displacement of these.

Cavity sterilizing agents such a phenol silver nitrate and germicidal agent, are irritating to pulpal tissue. Hence should not be used.

BIOLOGICAL CONSIDERATIONS AFFECTING PERIODONTIUMS

1. Mechanical trauma can result for any type of instrumentation. Hand instruments afford the operator more control and are less likely to cause injury than rotary instruments.
2. Excessive pressure during instrumentation if not applied parallel to long axis of tooth could bear some of periodontal fibers.
3. Vibrations for rotary instruments can lead to tearing of periodontal attachment.
4. Thermal trauma can cause ulcerations and burns in the periodontium.
5. Air coolants can detact the periodontal organ from the tooth at its dentino-gingival function.

6. Plaque materials and micro-organisms close to the periodontium could be driven apically post the gingival sulcus starting or accelerating periodontal breast down.
   Therefore, a physical barrier between areas on tooth being cut and adjacent provide protection from the above trauma. This includes use of rubber dam.
7. Margins of the cavity gingivally should be kept supragingival as far as possible. If they are keep subgingival there is mechanical trauma to the gingiva due to instrumentation or by the application of retraction cord. Moreover the restoration cannot be finished and polished adequately. Thus, the rough margins of the restoration continue to irritate the periodontium.

CONCLUSION

The very purpose of cavity preparation is deemed to failure if biomechanical principles of cavity preparation are not kept in mind.

Till the quest for newer material results in development of material having properties similar to enamel and dentine, the study of biomechanics is necessary for long-term success longevity of restoration and health of hard and soft tissues of tooth.

5 Porcelain Cavity Preparation

INTRODUCTION

As knowledge regarding the interceptive and treatment of dental diseases increases, the role of complex esthetic restoration of teeth has become more important. The esthetic restoration of teeth in years past had varying degree of success.

Dental ceramic technology is one of the fastest growing areas of dental materials research and development.

APPLICATIONS

1. Single unit crown
   – Porcelain jacket crown
   – Porcelain fused to metal
   – Castable glass ceramic crowns
2. Veneers for crowns and bridges
3. Artificial teeth
4. Inlays and onlays
5. Ceramic brackets used in orthodontia
6. Prefabricated labial veneers for natural teeth
7. Ceramic implants

PORCELAIN JACKET CROWN

Indication for Use

1. Conservation of tooth structure and maintenance of periodontal health.
2. All anterior teeth where esthetic is of prime importance.
3. Lower incisors where space is available.

Fig. 5.1: Class V cavity for porcelin

4. Limited use on the premolar teeth where the occlusion provides some protection of the buccal shearing cusps, e.g. cuspid disocclusion. In these cases the posterior teeth will generally have the cusps remaining intact.

Contraindication

1. In cases of parafunctional activity of the mandible, e.g. Broxism or where deflective malocclusion remain uncorrected.
2. Where occlusion clearance after tooth preparation is less than 0.8 mm, e.g. very thin teeth, deep incisal overjects with lingual wear facets.
3. Insufficient tooth support or where the preparation design causes sudden changes of thickness in the porcelain.
4. Molar teeth.

Preparation of Tooth

Incisal Reduction

- It is performed in two stages.
- The initial reduction is perpendicular to long axis of the tooth and 2 mm apical to the contemplated incisal edges of the finished restoration.
- The incisal reduction is not extended to adjacent teeth since proximal slicing removes these mesial and distal areas.
- It also avoids inadvertent contact with the adjacent teeth.
- The reduction is now modified to a plane perpendicular to inclination of mandibular teeth usually at a 45 degree angle to long axis of tooth.
- This allows compressive forces that are tolerated by porcelain.
- The use of incisal depth cuts promotes adequate and uniform reduction.
- Depth cuts are placed with tapered round ended diamond instrument.

Axial Reduction

- It is accomplished in several stages.
- The mesial and distal areas are 1st reduced to 2-5^{o} taper without establishing a shoulder.
- A long tapered diamond bur is used carefully.
- A lingual convergence of the anterior teeth is development with slices.

Facial Reduction

- It is performed with coarse flat ended diamond bur or no. 700 carbide bur.
- 0.8 mm of labial surface is removed while concomitantly establishing a preliminary shoulder in the form of heavy chamfer.
- Smooth controlled sweeping motions are suggested to reduce refining procedures.
- The incisal 2/3rd of the facial surface should be inclined lingually to provide uniform porcelain and suitable esthetics.
- 2-3 depth cuts are equally spaced over the mesiodistal dimension of the facial surface and should follow the facial tooth contour.
- After gross reduction shoulder form of finish line can be established.

Lingual Reduction

- It should follow gingival contour and join shoulder proximally.
- The cingulum is reduced using the tapered round end diamond instrument.
- The lingual wall formed during reduction should converge incisally relative to cervical aspect of facial surface until 3-5^{0} of taper is developed.
- The concave portion of the lingual surface must be reduced so that 1 mm of clearance is achieved with the opposite teeth in C.O. and throughout mandibular protrusive movements.
- A wheel or football shaped diamond instrument compatible with the lingual concavity is used.

Shoulder Formation

- A shoulder finish line is now formed in place of the heavy chamfer.
- Carbide bur with parallel sides and square end is used to created shoulder.
- Finish line is terminated at the crest of the gingiva in order to prevent damage to soft tissue.
- It is extended subgingivally.
    - To gain adequate retention.
    - To cover the existing restoration.
    - For esthetic reason.
- Special attention should assure the absence of any undercuts and adequate reduction for strength and esthetics.

PREPARATION FOR A CERESTORE AND DICOR CROWN

For Cerestore Crown

- The abutment preparation for the cerestore restoration is similar to a porcelain jacket.
- The circumferential shoulder should have a rounded gingivoaxial line angle that forms 90º cavosurface angle.
- The facial, lingual and interproximal areas are reduced no less than 1.2 mm for anterior teeth and no less than 1.5 mm for posterior teeth.
- The incisal reduction is 1.5 mm and occlusal reduction is 2 mm.

For Dicor Crown

- A circumferential shoulder with a rounded gingivoaxial line angle or a deep chamfer of approximately 120º is prepared.
- Axial reduction is 1.0-1.5 mm.
- Incisal or occlusal reduction is 1.5-2.0 mm.
- All prepared angles are rounded.

POST PREPARATION PROCEDURES

It includes:

- Formation of a silver plated die.
- Development of a platinum foil matrix over the die.
- Fabrication of the restoration on the foil matrix.

Die Fabrication

- Metal die is formed because (a) more resistant to abrasion during replacement and finishing of the casting. (b) it deforms less when platinum matrix is burnished and swaged.
- Epoxy resins are also employed as die materials.
  Advantages - Strength and hardness
  Disadvantages - Low setting time
  - Polymerization shrinkage
  – Incompatibility with certain impression material
- An axial slant is provided or die to
  a. Facilitate burnishing of platinum matrix.
  b. Its subsequent removal.
  c. To assure cervical margin fit of the finished porcelain restoration.
- When a number of restoration are being made at the same time, it is necessary to have the draw of the dies fairly parallel.
- After die is fabricated, bonnets are formed on it to test the accuracy of die and transfer of dies to master cast.
- Now the working cast are mounted on articulator in centric relation or centric occlusion.

TRY IN OF THE PORCELAIN JACKET CROWN

- The provisional restoration is removed and abutment is cleansed.
- The crown is placed on the abutment with a gentle application of force.
- The proximal contacts should be visually closed and provide firm resistance to passage of fine dental floss.
- Porcelain adjustments kits are used for contour reduction of porcelain restoration.
- A small protruding excess of porcelain at the cervical margin must be discretly removed.
- Centric occlusion is adjusted by having the patient exert very light biting force.

– Porcelain surface which has become rough after adjustment is polished again.

CEMENTATION PROCEDURE

– The cementation of full porcelain type esthetic crowns can be accomplished using a variety of luting cements.
– The crown is 1st placed in position without a test cement to note what color influence in the cement film might be most desirable.
– Pigment blend that simulates the dentin background under the crown are used.
– For the color trial powder is mixed with a glycerine and water 50% solution or with steel super glaze liquid.
– The crown is lined with the trial mix having a consistency of inlay setting cement and place on the abutment.
– By trial and observation, a suitable color background is determined.
– In preparation of final cementation, the inner surface of PJC should be etched.
– Etching is done with a flame staped diamond point operating under a water spray etching removes the glaze produced by firing, increases the retention capacity of the cement.
– The abutment is isolated and all moisture removed with a gentle stream of warm air.
– All gingival fluid must be controlled in order to attain the setting of the cement at the cervical margin.
– An inlay setting mix of cement is completed and a thin layer membrane applied to the abutment surface of the crown.
– The crown seated should 1st contact the lingual surface of abutment to eliminate the creation of air space in the labial aspect of the crown.
– The crown should be gently unbrated to facilitate the exit of excess cement.
– With the finger over the incisal edges of the crown and the adjacent teeth, the crown is held securely to its seat.
– When the cement has set, the holding force on the incisal edges is removed.

PORCELAIN FUSED TO METAL (PFM)

Indications

1. Single and multiple restoration for both anterior and posterior teeth.
2. Retainers for a RPD.
3. FPDs
4. Superstructure for splinted periodontal pockets
5. Mandibular anterior teeth where full shoulder preparation and prohibitive.
6. Peg shaped laterals or teeth with similar morphologic deviations.
7. Patients with a reduced interocclusal clearance or a strong masticatory musculative.

Advantages

1. Very high strength due to prevention of crack propagation from internal surface of crown by the metal reinforcement.
2. Improved fit on individual crowns provided by cast gold collar.
3. The only porcelain material that can be used in fixed bridge work and for splinting teeth.

Disadvantages

1. PFM crowns are susceptible to fracture.
2. May only be used in thickness of 1.5 mm or more due to the necessity of providing room for 0.5 mm of metal. This restructs their use for individual crown if there is a risk of overcontouring.
3. More difficult to create depth of translucency in the crown due to the dense opaque masking porcelain.
4. The fit of long span bridges or splints may be affected by the creep of the metal during successive bakes of porcelain.

5. Porcelain used in the metal ceramic tech are more liable to devitrifiation which can produce cloudiness.
6. More difficult to obtain good esthetics than regular or aluminous porcelain.

Requirements

1. *Pulpal Consideration*
   – Related pulpal responses after preparation and crown placement are realistic components on all fixed prosthodontics.
   – Near ideal preparations are possible if regimented caries control programme with amalgam restoration are performed prior to caries control.
2. *Restoration of function and anatomy*
   – The use of PFM veneer crowns with total occlusal coverage of porcelain for an entire quadrant presents a problem.
   – Problems associated are:
     a. Porcelain fracture
     b. Opposing tooth wear
     c. Supportive bone loss
3. *Investing tissues*
   – Overcontoured crowns, misplaced proximal contacts and poorly designed occlusal relationships sponsor adverse tissue response.
   – Splinting may add support to a tooth but limits the patients oral hygiene.
4. *Uniformity of tooth reduction*
   – Diagnostic aid in the form of radiograph and diagnostic cast enhance uniformity of tooth reduction.
5. *Instrumentation*
   – Ultra high speed cutting instruments are used.

Tooth Preparation

Incisal Reduction

– The incisal plane is reduced from 1.5-2.5 mm to have:
  a. suitable thickness of gold and porcelain.
  b. to ensure clearance in protrusive movements of the mandible.
  c. encourage esthetics
– Depth cut gauge facilitate the preparation.
– They are oriented parallel to the terminal protrusive functional pathway.
– The incisal edge is reduced using the tapered round end diamond instrument.

Facial Reduction

– A depth cut identifying the path of draw after a reduction of 1.5-2 mm reduction at the height of contour is placed in the midfacial.
– The grove of the unprepared tooth structure remaining are removed.
– This reduction is continued around the line angle to establish the profile of proximal reduction.
– Coarse grit or medium grit tapered round end diamond instrument is used.

Proximal Reduction

– It is accomplished to maintain parallelism with the line of draw without damaging or adjacent tooth.
– Align the instrument over the profile of the proximal reduction and with the orientation parallel to the line and draw, position to create a gingival ledge.

Lingual Reduction

– All the enamel is not removed of complete metal veneer crown.
– Adequate reduction for strength to withstand the forces of occlusion is the normal guideline.
– The angular axial wall is the only portion of the lingual surface to provide parallelism with the axis of draw.

- Examine the contour of cingulum wall and extend the reduction of this wall to join the proximal reduction.
- The reduction of lingual fossa depends on the design of the restoration.
- If the lingual surface of restoration is metal 1 mm of reduction is required. If full porcelain coverage reduction must be 1.5-2.5 mm.
- The dimensions of the reduction is gauged by depth cut grooves or divots.
- The cingulum is reduced with tapered round end diamond instrument.
- Lingual fossa is reduced with a wheel shaped or football shaped diamond instrument.

Gingival Margin Preparation

- Heavy chamfer provides acceptable marginal adaptation.
- Cervical margin is placed slightly below the crest of the soft tissue facially.
- The contour of the tooth is followed at the level of margins so that the margin is uniform in width.

Post Preparation Procedure

It includes:

1. *Die fabrication*
   - It is desirable to use a metal die.
   - Both silver and copper electroformed dies have excellent working characteristics.
2. *Articulations*
   - Working costs are mounted in centric relation or centric occlusion.
3. *Provisional Restoration*
   - It begins before the start of any tooth tissue reduction.
   - It should protect pulp, supporting tissue, weakened tooth, maintain tooth position and restore esthetics.

Trying and Cementation of PFM Crown

- The casting substructure for all veneered restoration are ideally tried in and adjusted prior to veneering.
- The margins are adjusted as are the contact areas when these are in metals.
- Any adjustments with the casting substructure should be made with ceramic bound abrasive stones (acrylic bound will contaminate the metal surface).
- All esthetic requirements should be satisfied before final cementation.

CEMENTATION

- Five classes of cements are available for cementation of cast restoration.

Zinc Phosphate

Advantages

Its viscosity, film thickness, working times and strength helps to achieve successful clinical record.

Disadvantages

- It is soluble in oral environment.
- Phosphoric acid is potential pulpal irritant.

Zinc Silicophosphate

Advantages

- More translucent than $ZnPO_4$
- Greater strength than $ZnPO_4$

Disadvantages

- Greater film thickness
- Potential pulp irritant

Zinc Oxide Eugenol

- Compatible with tooth tissue.
- Good short-term marginal seal.
- Low compressive strength so used as luting cement for provisional restoration.

Zinc Polycarboxylate Cement

- Exhibit moderate strength.
- Soluble in oral environment.
- Capacity of chemically bonding to tooth tissue.
- Pulpal compatibility

Glass Inomer Cement

- High compressive strength
- Low solubility
- Low film thickness
- Adhesion to dentin
- Exhibit cariostatic activity

Seating of Crown

- Cement is mixed and placed in thin coating.
- After proper isolation, crown is seated on prepared tooth surface.
- After cement has set, the site is cleaned of excess cement.
- Particular care is being taken to remove any fragment below gingival tissue.
- Floss the contact areas.
- Finally occlusion is revaluated.

CERAMIC VENEER

- Porcelain laminates are thin facing of ceramic porcelain affixed directly to teeth using a composite resin as bonding cement.
- Unlike composite veneer which are fabricated directly on patients teeth, porcelain veneer are constructed on refractory dies made from elastomeric impressions.
- Porcelain veneer has become an accepted procedure that promises the highest esthetic potential to date for restoration of anterior tooth defect.

Indications

1. Stained/defective restorations
2. Diastema
3. Fracture
4. Attrition
5. Adolescent teeth (large pulps)
6. Discoloration
7. Malformation
8. Malposition
9. Root exposure
10. Erosion/Abrasion

Contraindications

Bruxces, abrasive occlusal habits.

Advantages

1. High wear resistance
2. High resistance to staining
3. Excellent biocompatibility.
4. More premixed shades.
5. Good bonding to enamel.
6. Better fit possible to die.

Disadvantages

1. Shade is fixed except for adhesive.
2. Changes after placement are not possible due to loss of glaze.
3. Difficult to repair with resin.
4. Brittleness and possible breakage.

Advantages of Laminates over Ceramic Metal Crown

1. Frequently do not require anesthetic and are less stressful to patients.
2. Do not usually involve dentin, overting pulp sensitivity.

3. Maintain natural contacts and incisal guidance.
4. Limit tissue margin contacts to facial.
5. Provide a polishable, nonsoluble luting agent at the margin.
6. Eliminate metal collar or gingival metal display.
7. Do not usually require temporization.

Preliminary Tooth Modification

– Before starting preparation we will establish desired shade, correct preexisting restoration, defects or contour anomalies.
– A shade is selected from porcelain system that one half shade lighter than desired shade, this provides the dentist latitude and allows for slight darkening attributable to increased translucency with polymerization of compatible luting agent.
– Contour deficiencies greater than 1 mm resulting from caries, erosion or attrition are restored with GIC of suitable shade.

Tooth Preparation

– Because the line of draw for porcelain laminate is from facioincisal direction the normal incisogingial convexity of natural crown is maintained.
– The reduction varies with marginal location, enamel thickness, tooth discoloration, tooth-arch position, and functional requirements.
– A minimal thickness of 0.5 mm for porcelain veneer is readily accommodated.

Sequence of Tooth Preparation

– Controlled reduction is possible with multiple depth well or horizontal grooves prepared with various diameter ball diamond or round carbide bur.
– The bur is positioned so that limiting shank is laid parallel against enamel.
– Bur depth wells are placed gingival in mesiodistal center and at proximal angles.
– If incisal reduction is required a half round bur (0.7 mm) is used to notch the incisal edges in three more parallel positions.
– A gingival chamfer is placed at height of gingival crest unless severe discoloration mandates a subgingival margin to gain extra veneer thickness.
– The margin continues into interproximal areas to the height of the labiopalatal or labiolingual contour.
– If there are no restoration at proximals the preparation is extended just facial to contact area.
– If there are existing restoration or anomalies positioning of teeth contact is broken.
– If the existing tooth crown length is acceptable, the incisal margin is placed with a facioincisal bevel.
– The incisal preparation may be altered to allow incisal wrap of laminate terminating on a lingual chamfer when:
  a. Incisal thickness is too thin to support the veneer
  b. Along thinning of incisal edge 1.0-2.0 mm is desired
  c. The facioincisal margins is visible and unesthetic
  d. The incisal margin is structurally compromized
  e. incisal is subjected to functional stress
– The facial surface is uniformly reduced with a five diamond and water coolant to the peripheral margin and labial depth guides.
– The preparation is progressively refined and polished to remove contour irregularities.

– If a dark intensive discoloration remains a thin overlay of opaque composite resin may then be applied to partially mask underlying stain.
– The surface is smoothened and made ready for impression.

Impression

– An impression material that allows fabrication of several types of tray are used for impression.
– If preparation is limited to the anterior max teeth than an anterior stock tray is adequate.
– An alignate impression is suggested prior to preparation so that a custom tray may be fabricated.
– Custom tray is fabricated so that it is extended 5 mm gingival to gingival margin and cover half the palatal surface adjacent unprepared tooth and occlusal and incisal stop.
– When lower anterior teeth is prepared entire mandibular arch is covered in custom tray.

Try in of Porcelain Veneer

– Fabricated veneers are examined for fracture or excessive thickness.
– Color accuracy is verified at try in because internal etching of veneer reflect on overly white opaque appearance.
– Each veneer is trial seated with water soluble viscous media, glycerine or k-y jelly for stabilization and assessment of color and fit.
– Veneers are seated simultaneously to check for displacement from bulky proximal contacts.
– Select one central veneer to test basic shade of composite luting agent and need for supplemental opaque or color tests.
– Then trial veneer is placed or unetched enamel in selected composite luting agent plus all other color enhancements.

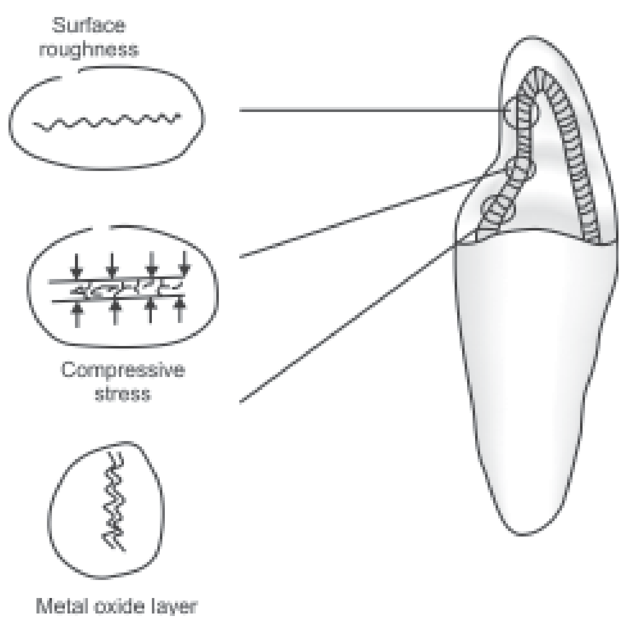


Fig. 5.2: Bonding

Bonding the Porcelain Veneer

- The veneer is placed in solution of alcohol or acetone to remove contaminants.
- Then they are rinsed, dried and arranged.
- A thin layer of silane coupling agent is burshed on etched surface of veneer and dried for minute.
- A thin layer of resin bonding agent is applied to the etched enamel.
- Also applied to the tooth side of silane primed porcelain veneer.
- A thin layer (0.5 mm) of selected shade of light cure resin bonding medium is placed on the tooth veneer is placed on the tooth side of the veneer carefully and lightly jiggled to place with a blunt instrument or light finger pressure.
- Excess bonding medium is removed with or disposable brush a;nd explorer.
- Margins are evaluated before the veneer is exposed to curing light.
- To ensure complete polymerization, the each from facial and lingual direction for a total exposure time of 80-120 sec.
- Use a microfine or superfines finishing diamond at slow speed with water spray to blend the margins.
- A smooth surface comparable to a glazed finish is achieved using flexible finishing disc or porcelain abrasive wheel and finishing with slurry polishing paste.

CERAMIC INLAYS AND ONLAYS

Advantages

1. Increased resistance to abrasion and attrition.
2. Reduced polymerization shrinkage stress since bulk of cavity is filled with indirect tooth colored restoration very little composite is used in cementation. Therefore, small amount of composite has relatively little shrinkage on polymerization resulting in less stress on restoration.
3. Ability to strengthen remaining tooth structure by bonding indirect inlays and onlays to conditioned tooth surface.
4. More precise control of contour and contact since there is greater access and visibility to all portion of cavity preparation.
5. Increased auxillary support.

Disadvantages

1. Increased cost and time need for temporary restoration.
2. Technique sensitive.
3. Ceramic being brittle can fracture if preparation does not allow adequate thickness to resist occlusal forces.

Indication

1. Esthetics – indicated in class I or class II cavities.
2. Tooth colored restoration should be considered for large class I or II restoration especially those that are wide facio-lingually and that require cusp coverage to strengthen remaining tooth structure and to contour the large restoration.

Contraindication

1. In patients who have bruxism or clencking habits.
2. Inability to maintain dry operative field.
3. Deep subgingival preparation.

Cavity Preparation

- Cavity preparation for ceramic inlays and onlays are essentially same as for cast-gold inlays and onlays minus beveling and secondary flowing.

- For initial cavity preparation tapering instrument is used to make straight facial and lingual walls that diverge occlusally to allow for insertion and removal of the restoration.
- The function of the side and tip of the instrument should be rounded to avoid sharp, stress inducing internal line angles.
- The gingival to occlusal divergence of the cavity preparation is increased from 2-5° per wall for cast metal inlays and onlays to 6-8°.
- The longitudinal walls are oriented to a single draw path usually the long axis of the tooth crown.
- The occlusal step should be 1.5 mm to 2 mm deep.
- Isthmus and groove extension should be 1.5 mm wide to decrease the possibility of fracture of restoration.
- Facial and lingual walls should be extended to sound tooth structure.
- Following the removal of remaining infected caries or previous restoration material from any internal walls or any undercut is restored to ideal position with a light cured glass ionomer cement.
- Cusp is capped if the extension is 2/3rd or greater from primary groove to cusp tip.
- If cusp is capped it should be reduced by 1.5-2 mm allowing 90 degree cavosurface angle.
- In centric holding cusp collar is prepared to remove the facial or lingual cavosurface margin from any possible contact with the opposing tooth.
- The axial wall of the collar should be sufficiently deep to allow for 1.0-1.5 mm minimal thickness of restorative material.

Proximal Box Preparation

- It is prepared identically as those for cast metal inlays.
- The facial, lingual and gingival margins of the proximal boxes should be extended to clear the adjacent tooth by at least 0.5 mm to have adequate access to the margins.
- For all walls, 90 degree cavosurface margins are desired.
- Possible extension of the gingival margin in enamel are preferred since deep margins are difficult to isolate during cementation.

Final Cavity Preparation

- A diamond instrument that has a similar shape as the carbide bur is used for final finishing to increase the surface roughness and the surface area for bonding.
- Remove all stains on the walls, which appear black or gray lines at the margins after cementation.
- Round all line and point angles to avoid stress concentration areas that could later fracture the tooth colored restoration.

Impression

Make an impression of the prepared tooth and an adjacent teeth which allows the restoration to be fabricated on a working cast in the laboratory.

Temporary

Provisional restoration is necessary. Eugend free temporary cement should be used to ensure proper setting of the final composite resin cement.

Try in and Cementation

Try in and cementation is more demanding for cast metal restoration due to:

a. Fragile nature of the ceramic material.

b. The requirement of near perfect moisture control.
c. The use of composite resin as a cement.
   – Very little pressure should be applied to the restoration during tryin.
   – Tooth colored composite cements require excellent moisture control for adhesive bonding so the use of rubber dam should be considered mandatory.
   – Pass the dental floss through the contacts to know the degree of excess contact and its location.
   – Use abrasive disk to adjust the proximal contour and correct contact relationship.
   – The cavity side of the inlay/onlay must be conditioned prior to cementation.
   – Specific acids are used to etch the cavity side of ceramic restoration.
   – After etching, the etched ceramic is treated with a sialanating agent to further improve the bond to composite cement.
   – Clear plastic matrix strips are applied in each affected proximal and wedged.
   – A dual cured composite cement is mixed and inserted into the cavity with a paddle shaped instrument or a syringe.
   – The cavity side of the restoration also is coated with composite cement and the inlay is immediately inserted into the cavity using light pressure.
   – Excess of cement is now removed with a thinly bladed composite instruments brushes or with the tip of explorer.
   – The restoration is now light cured from occlusal, facial and lingual directions for a min. exposure of 40-60 sec each direction.

Finishing and Polishing

– Inspect the margins in all areas with an explorer time.
– Fine grit diamond instruments are used initially to remove any excess cement back to the margins.
– Care must be taken to preserve the glazed surface of ceramic restoration.
– Slender flame shapes are used inter-proximally.
– Oval or cylinder shapes are used for occlusal surface.
– After using fine grit diamond instrument 30 fluted carbide finishing bur are used to obtain a smoother finish.
– Interproximally no. 12 surgical blade strips can be used to remove excess cement.
– Occlusion is now checked and adjusted.
– Repolishing is done in all the areas where corrections have been made by rubber abrasive points and cusps used at slow speed followed with a diamond polishing paste.

CONCLUSION

Restorative dentistry is constantly pursuing the ideal artificial material to replacing mixing tooth structure to while no such material exists, dentistry has made tremendous studies with introduction of carbide glass ceramic or dicor system and cerestore. These systems have been specially designed to allow fabrication of accurate restoration with outstanding esthetics.

6 Selection of Restorative Materials

INTRODUCTION

"A restoration may be defined as a material that is placed in the prepared cavity of the tooth so that its physiological, mechanical, functional, anatomical form and occlusion and esthetic requirement are properly restored and preserved and tooth is the area of restoration is protected as far as possible from recurrent caries".

One of the most important requirements is any operative procedure is the selection of the most suitable type of restorative material for the individual case presented. To determine this material, the patient must be viewed as a complex human organism whose teeth are as integral part which enable him to function as a healthy being. Therefore, any consideration of restorative measures must not be limited in scope to the tooth alone but take into account the correlation of this structure with rest of the organism.

The problem of selection of a material for a specific restoration is not an easy one and depends upon several factors.

Objectives

1. Arrest of lost tooth structure from caries or other causes.
2. Prevention of recurrent caries.
3. Restoration of maintenance of normal interproximal contact.
4. Establishment of proper occlusion.
5. Esthetics.
6. Resistance against forces of mastication.

Requisites of Ideal Restorative Material

According to GV Black, most desirable qualities of a restorative material are:

1. Indestructibility in fluids of the mouth
2. Adaptability to the walls of cavities
3. Freedom from shrinkage or exparison after having been placed in cavities
4. Resistance to attrition
5. Sustaining power against forces of mastication

   Qualities of secondary importance as outlined by Black are:

   1. Color
   2. Low thermal conductivity
   3. Easy manipulation

However, there are other qualities which are ideal restorative material should possess.

1. Non-toxic and non-irritant to pulpal and gingival tissues
2. Be trimmed and polished without difficulty
3. Wear should be similar to that of enamel
4. Have as ability to protect adjacent tooth from recurrence of caries
5. Have a coefficient of thermal expansion similar to that of enamel and dentin
6. Have a low water absorption
7. Be radiopaque

8. good shelf life
9. economical
10. longevity of life

Types of Restorations

1. ***Permanent restorations:*** Those which satisfy the objectives of a restoration for 20 to 30 years, e.g. direct filling gold restorations, amalgam.
2. ***Temporary restorations:*** These are the restorations which are expected to last for only a short period, e.g. few days or a few week. They may serve only till the time pulp heals or a more long lasting restoration is fabricated and inserted, e.g. ZnOE.
3. ***Intermediate restorations:*** Sometimes a restoration is desired for several months or longer, e.g. in case of rampant caries patient, caries may be removed and restoration placed till patient moves to low caries risk status and a permanent restoration is placed.

Other Classification as Following

1. Temporary
   a. gutta percha
   b. Zinc oxide eugenol
   c. Zinc phosphate cements
   d. Self-curing acrylic resin
2. Intermediate
   a. Cements – ZnOE
   b. Crown forms
      - Plastic
      - Tin
      - Aluminium
   c. Customized acrylic restorations
   d. Cast restorations

Classification basis on their working properties as following:

1. Plastics
   a. Amalgam
   b. $ZnPo_4$
   c. Gutta percha
   d. Silicate cement
   e. Self-curing acrylic resin
2. Non-plastics – gold

Table 6.1: Restorative materials

Materials	*Direct filling*	*Indirect filling*
Non-metallic or tooth colored	1. Microfilled composites 2. Hybrid composites 3. Compomer 4. Resin modified GI 5. Conventional GI	1. Composites 2. Ceromer 3. Polymer glass 4. Ceramics 5. Glass ceramics 6. Vereered metal
Metallic	1. Amalgam 2. Direct filling gold 3. Metal reinforced GI 4. Gallium alloy	1. High gold casting alloy 2. Low medium casting alloy 3. Non-precious alloy

FACTORS AFFECTING SELECTION

Relates to the Patient

Age

- Amalgam is indicated is young patients with high caries incidence.
- Older patients enable to give long sittings direct filling gold are not indicated.

Physical Status of Patient

- Medically compromised patient may require early meaning appointments, special positioning of rest. Gold restorations are not preferred while amalgam or GIC may be preferred.

Oral Hygiene

To a patient with good oral hygiene therefore less chances of recurrent caries so gold restorations may be preferred.

Metal Status of Patient

In mentally retarded patients, procedures requiring longer time are contraindicated. Also as oral hygiene is poor and chances of recurrence of caries are high, so costly restoration should not be given.

Economics

- Patients economical status should be considered.
- Mentality and will power of patient
- Esthetic appearance.

Relates to the Tooth

1. ***Types of forces falling on tooth and character of bite:*** The predominant stress on posterior teeth are compressive while is anteriors they are tensile stresses. Therefore, materials like amalgam and gold are preferred is posteriors.

   In cases of heavy occlusal forces, ceramic restorations may fracture if bulk is insufficient, so should be avoided.
2. ***Size of carious lesion:*** In posterior teeth, greater the involvement, more likely a gold restoration may be considered.

   Depending on the extent of lesion, cuspal coverage or placement of pin for retention is to be considered.

   Incipient lesion in anterior teeth may be restored with composites/GIC.
3. ***Prognosis/status of tooth:*** Even though a tooth may have large carious lesion but because of its questionable prognosis, amalgam may be preferred over gold restoration.
4. Endodontically treated tooth
5. Site of lesion :-

   Class I
   - If pit and fissure caries not extensive amalgam or direct filling gold.
   - If extensive – inlays, onlays or crowns

   Class II
   - Extensive lesions – gold inlay – material of choice
   - If facial/lingual involvement – onlay or crown

   Class III
   - Esthetic materials
   - Amalgam in distal surface of caries

   Class IV
   - Esthetic/tooth colored materials are materials of choice

   Class V
   - Extensive lesion – then full crown restoration
   - Class II & V complex - crown
6. ***Depth of lesion:*** In deep cavities, adequate base has to be given beneath the metallic restorations.
   - Types of restoration is adjacent or opposite tooth
   - Position of tooth in arch
   - Friability of enamel
   - Sensitivity of dentin
   - Condition of pulp
   - Future service of tooth to be restored

Relates to Materials

Primary Factors

- ***Solubility resistance:*** Solubility is measured by weight loss after the restoration is placed in various solutions or saliva.

  Solubility of material will cause microleakage leading to failure of restoration.

- ***Adaptability:*** Refers to degree of mechanical interlocking and sealing between the material and the wall of cavity preparation. Material should properly adapt to the tooth.
- ***Dimensional stability:*** A lack of shrinkage or exparsion following material placement is desirable.
- ***Strength:*** Occlusal surfaces of posterior teeth, incisal edges of anterior teeth receive considerable stresses during mastication, so restoration of these surfaces requires materials with high strength.
- ***Abrasion resistance:*** Evaluated by the restoration following the application of abrasives and other substances. The material selected should have adequate abrasion resistance.
- Esthetics

Secondary Factors

- ***Low thermal conductivity:*** Conductivity has to be controlled is order to prevent pulp injury.
- Easy of manipulation
- ***Resistance to corrosion:*** Cast gold has resistance to corrosion while low as alloys tarnish more rapidly than high Cu alloys.
- ***Ductility:*** This properly plays an important role is marginal integration. Cohesive according is most ductile of all gold restorative materials.
- Capability of retaining a good polish

Restorative Materials

Amalgam

Indications

- Cl-I and CI-II cavities
- Cl-II cavities where cervical margin of box is subgingival or is composed entirely of dentin
- Cl-V restorations where esthetics is not of primary concern
- In extensive caries lesion as a core building material
- Cl-III distal aspect of caries
- Pin retained restorations.

Contraindications

- Anterior teeth and clearly visible surface of posterior teeth.
- Allergic to material
- Treatment of incipient or early fissure caries
- Patients with proven amalgam induced lichonoid lesions
- Extensive carious lesions is in which remaining tooth structures requires support
- Gallium

Long-term results are awaited.

Indications and contraindications are similar to amalgam.

Direct Filling Gold

Indications

- In small carious lesions in pits and fissures of most posterior teeth and lingual surface of anteriors.
- In class II lesions where marginal ridge is not subjected to heavy occlusal forces.
- Cl-V lesions, Cl-III lesions.

Contraindications

- Teeth with large pulp chambers
- Periodontically weakened teeth with questionable prognosis
- Economics
- Endodontically treated teeth
- In handicapped, elderly or very young patients.

Cast Metal Inlays and Onlays

Indications

- Extensive Cl I and II lesions. (Onlay when failing restoration but facial or lingual surface is intact).
- Cl III and IV restoration where there is minimal display of metal.
- Class V restoration is posterior teeth.
- Superior central of contours and contacts is desired:
  - RCT treated teeth
  - Fracture lines
  - Diastema closure
  - Occlusal plane correction.

Contraindications

- Economics
- Extensively carious anterior restorations
- Younger age group in whom oral hygiene is grossly neglected.

Composites

Indications

- Class I and II cavities that can be approximately isolated and where some centric contact on tooth structure is present.
- Class V defects.
- Class VI cavities.
- Vereers for metal restorations.
- Repair of fractured areas.
- Interim restorations.

Contraindications

- Isolation is not possible
- All occlusal contacts will be on the composite material
- Heavy occlusal stresses
- Deep subgingival areas where is difficult to prepare and restore.

Ceramics

Indications

- Anterior teeth where esthetics is of prime concern.
- Proximal regions of anterior teeth where metallic restoration is acceptable.
- Patient with good oral hygiene.
- Cavity free from undercuts.

Contraindications

- Poor oral hygiene
- Teeth exhibiting gross wear
- Access is poor.

GIC

Indications

- Restoration of erosion/abrasion lesions without cavity preparation.
- Sealing and filling of occlusal pits and fissures.
- Restoration of deciduous teeth.
- Class V carious teeth
- Restoration of Cl III caries lesion preferably using lingual approach.
- Repair of defective margins is restorations
- Minimal cavity preparation of approximal lesions.

Contraindications

- Lesions on stress bearing sites
- When moisture control not feasible.

Resin Reinforced Glass Ionomera

Indications

- Underneath metal or porcelain fused to metal crowns when RRGI is used as a gingival crown repair.

- In large deep wrap around Cl III – Cl V combination restoration where light can not penetrate.
- As a internal filler inside large and deep restorations where traditional composite is to be used externally.

Compomers

Indications

- Fissure sealing
- Conservative class I for permanent teeth
- Cl I and II for primary teeth
- Cl V cavities
- Blocking of under cuts etc.

Contraindications

Poorly accessible areas where light cannot penetrate large carious lesions.

CONCLUSION

Although the search for as ideal restorative material still continues but out of the present not the ideal material for a restoration depends on the case selected.

7 Restoration of Teeth with Silver Amalgam

RESTORATION OF TEETH WITH SILVER AMALGAM

For nearly 160 years dental amalgam has been used more than any other restorative material. The first dental silver amalgam is supposed to have been introduced by Bell of England in 1819 and later used by Tidwon in Paris in 1826 in the form of paste.

But according to a statement by Dr. DM Cattlele, it was introduced in 1833. In the beginning of, many dentists made amalgam by Crawcom brothers under the name of "Royal Mineral Succedaneum amalgam by filling silver coin and mixing the filling with mercury. This produced a hardest mass which was difficult to mix hardened very slowly and changed form enormously.

Thus led to the addition of tin to the silver which was accomplished by rubbing tin fail with the silver filings thus breaking it up into fine masses which united with mercury. This produced a more plastic mass, which set more rapidly and amalgamated much easier. Later, an alloy of silver on tin was made by melting the metals, which was a marked improvement over the pure plain of mixing the metals in a cold state.

Ever since into its introduction, score generation of amalgam have come up. But the success and longevity of the amalgam restoration depends upon the cavity designs and its manipulation. This part of the chapter aims at discussing the cavity preparation for cavity amalgam for different classes of cavities and as a retrograde material.

Indications for Silver Amalgam

1. Class I cavities
2. Class II cavities
3. Class III cavities particularly the distal surface of canine.
4. Class V restorations particularly in cases where aesthetics is not prime consideration.
5. In extensive carious lesions as a core building material in conjunction with retentive aid like pin.

Contraindications for Silver Amalgam

1. Anterior teeth and clearly visible surfaces of posterior teeth.
2. Allergy to any component of amalgam proven by skin test.
3. Patients with proven amalgam induced lichenoid lesions.
4. Treatment of incipient or early primary fissure caries.
5. In extensive carious lesions in which the remaining tooth structure requires support.

Advantages of Silver Amalgam

1. High compressive strength
2. Insolubility in oral fluids

3. Wear characteristics similar to enamel
4. Less dimensional change
5. Good marginal adaptation
6. Ease of manipulation
7. Capability of taking high polish
8. Economical
9. Very good clinical performance

Bohannan reported life expectancy of amalgam to be 4-8 years.

Robinson sand – 20 years.

Markeling found that it is 40 years in some restorations.

Disadvantages

1. Inharmonious color.
2. Tendency for molecular change, i.e. flow and creep.
3. Poor edge strength.
4. Marginal deterioration.
5. High thermal conductivity.
6. Prone to tarnish and corrosion.
7. Mercury toxicity if not used properly.

CAVITY PREPARATION

Class I Cavity

Armamentarium

1. Rubber dam
2. No 245 pear shaped tungsten carbide bur.
3. Excavators
4. No 2 round bur

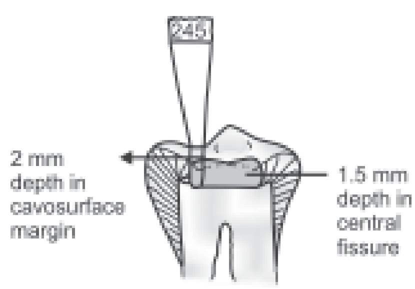


Fig. 7.1: Class-I Cavity (1.5 mm depth)

Conservative Cavity Preparation (Fig. 7.1)

1. Isolation is achieved with the help of rubber dam.
2. Initial cavity preparation:

The outline form for the class I occlusal cavity preparation should include all of the occlusal pits and fissures in such a manner that sharp angules in the marginal outline are avoided. For maxillary premolars, the outline is frequently butterfly shaped (Fig. 7.2) because of extension to include the developmental fissures.

A no 245 bur with a head length of 3 mm and a diameter of 0.8 m is used to prepare the class I cavity preparation. The sites of this bur are slightly divergent edge-wise which produce an occlusal convergence to the facial and lingual walls providing adequate retention form to the cavity preparation. The slightly rounded corners of the end of the bur produce slightly rounded internal line angles that render the tooth more resistant to fracture for occlusal force. The no 330 bur is a smaller version of 245 bur which is used for conservative amalgam preparation. The cavity preparation is begin by entering the deepest or most carious pit with a punch out using the no. 245 carbide bur at high speed with air water spray. A punch cut is performed by orienting the bur so that its long axis parallels the long axis of the tooth crown and then inserting the bur

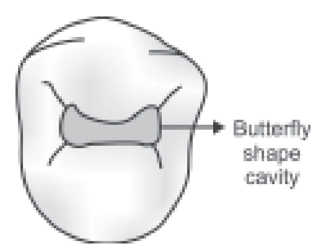


Fig. 7.2: Butterfly shaped cavity (maxillary premolar)

directly into the faulty pit when the pits are equally faulty enter the distal pit the bur should be positioned so that its distal aspect is directly over the distal pit, thereby minimizing extension into the marginal ridge.

- As the bur enters the pit, the proper depth of 1.5-2 mm should be established (1.5 central fissure, 2 mm external). The desired pulpal depth is usually 0.1-0.2 mm into dentine.
- If extension into the marginal ridge is required to include a fissure or caries, slight alting of bur (not more than 10^0) is done to create a slight occlusal divergence to proximal wall to prevent undermining the marginal ridge of its dentin support.
- The distance from margin of such an extension to the proximal surface should not be less than 1.6 mm in premolars and 2 m in molars.
- While maintaining the bur orientation and depth, extend the preparation distofacially or distolingually to include any fissures that radiate from the pit. Core should be taken not to undermine the marginal ridge. When these fissures require extensions of more than a few lengths of millimeter, consideration should be given to changing to a smaller diameter bur such as a no. 169 L or to using enameloplasty. Continuous to maintain the bur orientation and depth and with intermittent pressure, extend along the central fissure towards the mesial pit. This will create a flat pulpal floor. However, in larger teeth with steep cuspal inclines, the pulpal floor may follow the rise and fall of occlusal surface in order to maintain a more uniform pulpal depth.
- The remainder of the occlusal enamel defect are included in the outline, and the facial and lingual walls are extended, if necessary to remove enamel undermined by caries. A strong ideal enamel margin should remain: one that is made up of full length enamel rods resting on sound dentine supported on the cavity side by shorter rods also resting on sound dentine.

Thus, conservative class I cavity preparation should have an outline form with gently free flouring curves and distinct. A faciolingual width of no more than its 1.5 mm and depth of 1.5 to 2 mm are considered ideal. The pulpal floor depending on the enamel thickness is usually in dentine.

Convenience form requires that the extent of the preparation allows adequate access and visibility.

Resistance form is provided by sufficient area of relatively flat pulpal floor in sound tooth structure to resist forces directed in the long axis of the tooth, providing a strong stable seat for the restoration.

i. Minimal extension of external walls and thus not weakening the tooth
ii. Strong, ideal enamel margins sufficient depth to result in adequate thickness of the restoration for the resistance to fracture and walls.

Retention form (Fig. 7.3) is provided by the parallelism or slight occlusal convergence of two opposing external walls.

Enameloplasty (Fig. 7.4) of the remaining fissure can be done with a flame shaped diamond stone if the remaining fissure is no more than one-third thickness of enamel.

Final Cavity Preparation

Removal of Any Remaining Enamel Pit/ Fissure and Infected Dentine

- If several enamel pit/fissure remnants remain in the floor or if a central fissure

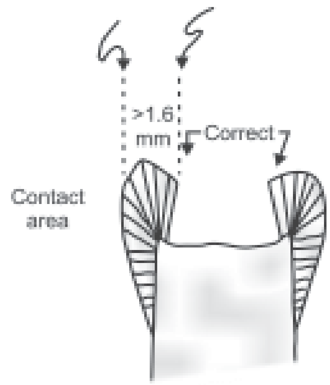


Fig. 7.3: Retention form

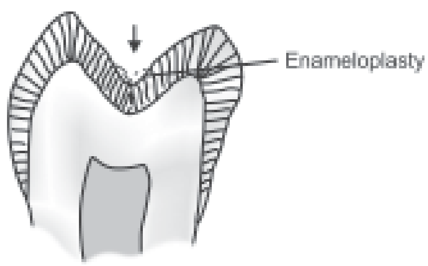


Fig. 7.4: Enameloplasty

remnants extend over most of the floor deepen the floor with the no 245 bur to eliminate the fault or to uncover the caries to a maximal preparation depth of 2 mm. However, if the pit and fissure remnants are few and small, remove them a round carbide bur.

- Removal of remaining infected dentine is best accomplished using discoid type spoon excarator or slowly revolving round carbide bur of appropriate size when removing infected dentine, stop the excavation when a hard or firm feel to tooth structure is achieved.
- After removal of remaining infected dentine a minimum of three flat seats should be three for adequate resistance form.

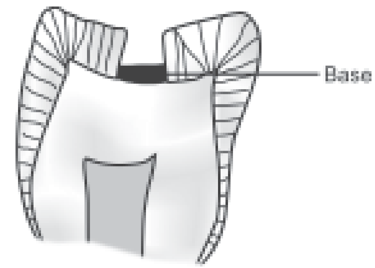


Fig. 7.5: Pulp protection

Pulp Protection (Fig. 7.5)

If the cavity preparation is of ideal depth, no liner or base is indicated. In moderately deep carious excavation, place a thin layer of 0.5-0.75 m of quick setting zinc oxide eugenol cement.

Finishing of External Walls

It is usually finished during early steps. It is important to provide a 90-100 degree cavosurface angle which should result in 80-90 degree amalgam at the margins.

Cleaning, Inspecting and Varnishing

A final inspection of the preparation is done. The cavity preparation should be free of debris and visible moisture. It has been demonstrated that air water spray is effective in removing bacteria from the cavity preparation. Apply two layers of cavity varnish before inserting the amalgam.

Cavity Preparation for Extensive Caries

Caries is extensive if the distance between infected dentine and the pulp is judged to be less than 1 mm.

With extensive caries, concern during initial cavity preparation regarding outline resistance and retention forms is deferred until after the excavation of infected dentine and insertion of base.

Initial cavity preparation includes cutting to a depth of 1.5-2 m. The cutting is extended laterally to remove all enamel undermined by caries. This established premaring resistance form.

Initial Cavity Preparation

It includes removal of remaining infected dentine similar to conservative preparation.

If **pulp protection** use a non-pressure flow technique to insert a 0.5 to 0.75 mm minimal thickness of quick setting calcium hydroxide material as a base to cover all areas of near exposure or exposure.

Secondary Resistance and Retention Form

If excavation of infected dentine has removed most or all of flat pulpal floor that was initially prepared establish at least three flat seat in dentine 0.2 mm from DEJ. Somewhat equally spaced around the periphery of the excavation.

Secondary retention is undercut areas that are sometimes left in dentine following removal of infected dentine and that are not covered by the base.

All the subsequent steps are similar to conservative preparation.

Class II Cavity

Armamentariums

- Rubber dam
- No. 245 bur
- 10-7-14 no enamel halchet
- 12-7-8 binangle chisel
- No 2 round bur
- 169 L bur
- First placement of rubber dam is done
- Insertion of interproximal wedges is done

The wedge depresses and protects the rubber dam and underlying soft tissues, separates the teeth slightly and can serve as a guide to prevent gingival over extension of proximal bones.

Initial Cavity Preparation

Occlusal step: Outline form of the occlusal step of class II cavity preparation for amalgam is similar to outline form for class I cavity preparation.

No. 245 bur is inserted into the pit nearest the involved proximal surface and extension of the cavity margins are done similar to class I. the depth is kept at 1.5-2 mm, i.e. 0.2 mm into dentine.

A **dovetail retention** form is given by including the deep developmental fissures radiating from pit of uninvolved proximal surface (i.e. distal pit in MO proportion).

Before extending into the involved proximal marginal ridge, visualize the final location of the facial and lingual walls of the proximal box relative to the contact area. This will prevent overextension of the occlusal outline form to accommodate poor planning in journey the occlusal outline form with the proximal outline form.

While maintaining the established pulpal depth and with the bur parallel to the long axis of the tooth crown, extend the preparation mesially, slopping 0.8 mm short of cutting through the marginal ridge into the contact area. The occlusal step in this region is made slightly wider faciolingually than in class I preparation because additional width is necessary for the proximal box.

Proximal Box Preparation

Proximal Ditch Cut (Fig. 7.6)

The initial procedure in preparing the outline form of the proximal box is the isolation of the proximal enamel by the proximal ditch cut.

- With the same orientation of the bur, position it over the pulpal floor next to the remaining mesial marginal ridge allow the end of the bur to cut a ditch gingivally along the exposed dentino-enamel junction, two-thirds at the expense of dentine and one-third at the expense of enamel (i.e. 0.5-0.6 mm in dentin and 0.2-0.3 mm in enamel.
- Pressure is directed gingivally and lingualy towards the mesial surface to keep the bur against the proximal enamel, while the bur is moved facially and lingually along the DEJ. Extend the ditch gingivally just beyond the caries of the contact width whichever is greater.

Facial and lingual extension of the ditch should be such that mesiofacial and mesiolingual margin should clear the adjacent tooth by 0.2-0.3 mm. This provides the necessary convenience form. The gingival margin should clear the adjacent tooth in small preparation by 0.5 mm. Extending gingival margins into the gingival sulcus should be avoided. The axial wall depth is 0.5-0.6 mm into dentine. When extension places the gingival margin in cementum, the pulpal depth of the axiogingival line angle should be a minimum of 0.75-0.8 mm.

The proximal ditch cut is diverged gingivally so that the faciolingual dimension at the gingival is greater than at the occlusal. This contributes to retention form.

To conserve tooth structure, the outline facially and lingually is not carried beyond proximal contact.

Completion of Proximal Extensions (Fig. 7.7)

- Next, make two cuts one starting at the facial limit of the proximal ditch and the other starting at the lingual limit; extending toward and perpendicular to the proximal surface until the bur is nearly through the enamel at contact level. The side of the bur may emerge slightly through the surface at the level of the

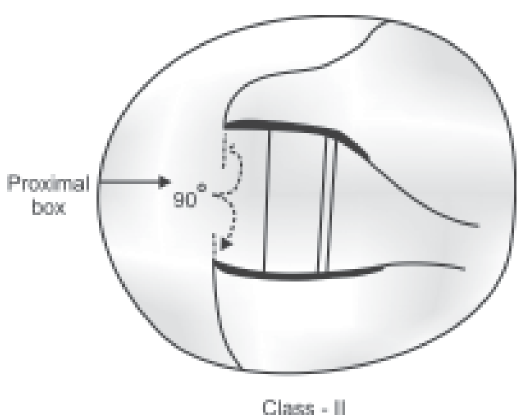


Fig. 7.6: Proximal ditch cut

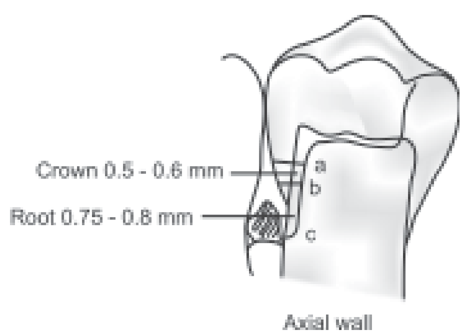


Fig. 7.7: Proximal extensions

gingival floor. This weakens the remaining enamel by which the isolated portion is held.

- If this level is judged to be insufficiently gingival, additional gingival extension should be accomplished using the isolated proximal enamel that is still in place to guide the bur. However, the remaining wall of the enamel breaks away particularly at high speed. If additional cutting is required at this stage, a matrix band is placed to prevent cutting of proximal surface of adjacent tooth.
- With 10-7-14 enamel hatched or binangle chisal (12-7-8) or both, cleave away the remaining undermined proximal enamel establishing the proper direction to the mesiolingual and mesiofacial walls proximal margins having cavosurface angles of 90 degree are indicated.

The weakened enamel along the gingival wall is removed by using the enamel hatchet in a scraping motion.

Incorporation of Reverse Curve (Fig. 7.8)

It we view from the occlusal, the direction of the mesiofacial enamel wall is parallel to the enamel rod direction, thus usually creating a reverse curve in the outline. This curve thus helps in the resistance form as it conserves the triangular ridges of the cusp. Moreover, when the contact area is broad the curve facilitates. The convenience form by bringing the buccal proximal wall in the membrane without unnecessarily cutting tooth structure.

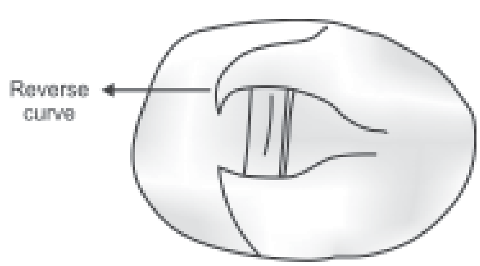


Fig. 7.8: Reverse curve

Primary resistance and retention form is thus provided by:

i. the pulpal and gingival walls being relatively flat and perpendicular to direction of forces.
ii. Restricting extension of walls to allow sufficiently strong cusp and ridges to remain.
iii. Restructuring occlusal outline form to areas receiving minimal occlusal contact.
iv. Cutting of internal line angles including axiopulpal line angle providing enough thickness of restorative material to prevent its fracture under mastication.

Primary retention form is provided by the occlusal convergence of facial and lingual walls as well as dovetail design of occlusal step.

After completing the initial cavity preparation, the adjacent proximal surface should be evaluated. Recontouring of proximal restoration if required is done.

Final Cavity Preparation

Removal of any remaining defecting enamel and infected carious is accomplished as in class I preparation. The presence of infected carious dentine on a portion of either pulpal or axial wall does not indicate deepening the entire wall. This is removed with the excavator or slow speed round bur and liner or base.

If caries remains on part of gingival wall then a part or whole of gingival wall is extended gingivally. Extending only a part of gingival wall facilitates matrix placement which would not have been possible if the entire gingival walls is extended gingivally.

Pulp protection similar to class I. The William's periodontal probe or a cement placing instrument is suitable to convey the material to the excavated area.

Secondary Resistance and Retention Forms

Proximal locks improve the retention form of cavity as well as increase fracture resistance of amalgam.

Using a No. 169 L bur with air coolant and reduced speed, prepare a retentive lock in asciolingual line angle. There are four characteristics of proximal locks.

1. Position
2. Translation, i.e. movement gingivally to occlusally.
3. Depth, i.e. 0.5 mm at gingival wall which becomes shallower occlusally.
4. Occlusogingival orientation refers to tilt of 169 L bur which dictates the occlusal height of the lock (Fig. 7.9). Narrow proximal boxes permit shallow proximal locks. Wide proximal boxes acquire deeper locks.

Slots in gingival may be used to provide additional retention. Generally these are prepared with a No. ¼ or ½ bur 0.5-1 mm deep gingivally, 2-3 mm in length faciolingually and 0.2-0.3 mm inside the DEJ.

Pot holes may be used to provide additional retention. They are usually prepared with a No. ½ or 1 bur 0.5-1 mm deep gingivally and 0.2-0.3 mm inside the DEJ.

Finishing external walls: The cavity walls should not have unsupported enamel and marginal irregularities if present should be corrected. But joint relationship of enamel and amalgam creates strongest margin.

Gingival marginal trimmer is used to be given gingival bevel of 20 degree in the enamel by gingival wall (Fig. 7.10).

Final procedures: Cleaning, inspecting and varnishing.

The cavity preparation may need cleaning with air/water spray, a wet cotton pellet or 3 percent solution of hydrogen peroxide. Inspect the cavity preparation for detection and removal of debris or of base/liner where unwanted. Then 2 coats of varnish are applied.

Modification in Cavity Design

Simple box preparation (Fig. 7.11): Almquest, Cowan, Lambert and Markley recommend a proximal box preparation without occlusal step.

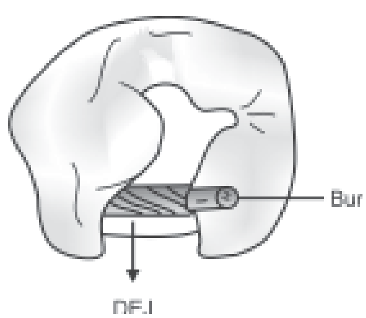


Fig. 7.9: Retention lock

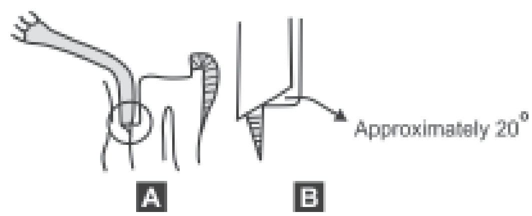


Fig. 7.10: Gingival bevel

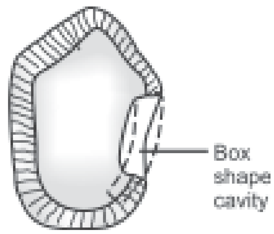


Fig. 7.11: Simple box preparation

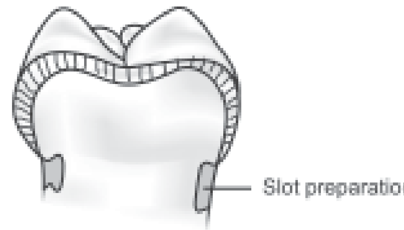


Fig. 7.12: Slot preparation

To maximize retention, preparations with facial and lingual walls that almost oppose each other and advised this type of preparation should be limited to a proximal surface with a narrow interproximal contact allowing minimal facial and lingual extension. To compensate for the lack of an occlusal dovetail, the proximal retentive locks should have a 0.5 mm depth at gingival point angle tapering to a depth of 0.3 mm at the occlusal surface.

Slot Preparation for Root Caries (Fig. 7.12)

Older patient with gingival recession usually have caries gingival to contact. So the cavity preparation is usually approached from the facial and has the form of slot.

After isolation of the operating field, prepare initial cavity outline form from a facial approach with a No. 2 or 4 bur using high speed and air water spray.

Outline form extension of the external walls to sound tooth structure is at a limited depth pulpally 0.75-1 mm at gingival aspect 1-1.25 mm at occlusal walls. External walls should form a 90 degree cavosurface angle. With facial approach, the lingual wall should face facially possible. The facial wall must be extended to provide access or visibility or convenience form.

In final cavity preparation use the No. 2 or 4 bur to remove any remaining infected carious dentine on the axial wall. If indicated apply base or liner.

Prepare retention grooves with a No. ¼ bur depth with into occlusal and gingivo-axial line angle 0.2 mm inside DEJ or 0.3-0.5 mm from cemental margin. The depth is 0.25 mm varnish is applied as usual.

Rotated Teeth

When the tooth is rotated at 90 degree and the proximal lesion is on the facial on lingual surface, the preparation may require an esthmic that includes the cuspal eminence.

Tunnel Cavity Preparation

Knight advocated this preparation. This preparation joins an occlusal lesion with a proximal lesion by means of prepared tunnel under the involved marginal ridge.

Cavity Preparations Involving both Proximal Surfaces

MOD cavity preparation is similar to two surface cavity preparation for a single proximal surface except that both proximal surfaces are included. To preserve the strength of tooth, one should maintain ideal pulpal floor depth and occlusal isthimus width whenever is possible.

Class III Cavity Preparation

Armamentarium

- Rubber dam
- No. 2, ½, ¼ round bur
- No. 245 bur
- High speed handpiece
- 8-3-22 hoe

The cavity preparation on the distal of the maxillary canine will be discussed. Usually the lingual approach is recommended except for when the lesion extends facially. In this case facial approach is preferred.

1. Isolation of the operating site with rubber dam
2. Placement of a wedge.

Initial Cavity Preparation (Fig. 7.13)

Enter the tooth with a No. 2 bur on the distolingual marginal ridge. A no. ½ or 1 bur should be used when the tooth is small for conservation of tooth structure. The bur is positioned so that the entry cut will penetrate into the carious lesion, which is usually gingival to and slightly into the contact area. The bur is held so that its long axis is perpendicular to the lingual surface of the tooth.

Penetration through the enamel should place the bur in such a position that additional cutting will both isolate the proximal enamel affected by caries and remove some or all of infected dentine and will be at a limited depth 0.5 to 0.6 mm pulpally of DEJ or at a 0.75 to 0.8 m depth when gingival margin is in cementum (Fig. 7.14). This 0.75 mm pulpal depth allows 0.25 mm distance between the retention groove and the gingival margin.

Ideally for a small lesion, the facial margin is extended 0.2 to 0.3 mm into the facial embrasure. With a curved outline from the incisal to the gingival margin. The lingual outline blends with incisal and gingival margins in a smooth curve, creating a preparation with little or no lingual proximal wall. The cavosurface angle should be 90 degrees at all margins.

The facial, incisal and gingival should meet the axial wall at right angles. The lingual wall meets the axial wall at an obtuse angle or may be continuous with the axial wall. The axial wall should be uniformly deep into dentin and follow the faciolingual contour of the external tooth surface.

Incisal extension to remove carious tooth structure may eliminate the proximal contact where removal of carious or undermined enamel permits it is better to leave the incisal margin in contact for retention, longevity and esthetics.

When preparing a gingival wall that is near the level of the dam, it is important to place wedge in gingival embrasure.

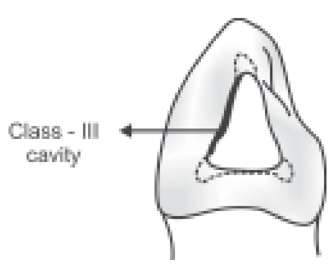


Fig. 7.13: Class-III Cavity

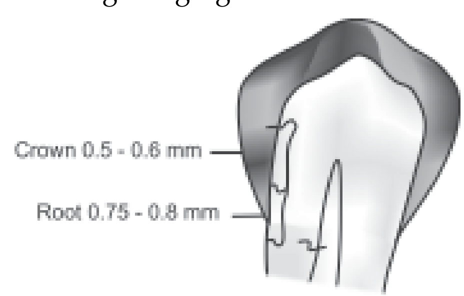


Fig. 7.14: Class-III Cavity (depth)

Complete the initial cavity preparation by using a No. ½ bur to accentuate the axial line angle particularly the axiogingival. The No. ½ bur may also be used to smooth the roughened, undermined enamel produced at the gingival and facial margins by No. 2 bur.

Thus, the initial cavity preparation has established the convenience form the further instrumentation.

The resistance form is established by (a) proper depth of cavity (b) direction of wall of cavity parallel to enamel node (c) preserving as much as sound tooth structure, as possible (d) no start internal line or point angles.

Final Cavity Preparation

Removal of any remaining infected dentine using a slowly revolving round bur No. 2 or 4 are discord type spoon excavator.

Pulp protection in the form of liner/base in moderate to deep carious lesion.

Secondary resistance and retention form–

As resistance form is already established, the retention form is given by preparing a gingival groove and an incisal cone and in extensive preparation in the form of dove tail.

Gingival retention groove is prepared by placing a no. ¼ bur rotating at low speed in axiofaciolingual point angle and move it lingually along the axiogingival line angle with depth wise direction of cutting mostly gingival and slightly pulpal. The depth of groove should be half the diameter of ¼ bur, i.e. 0.25 mm. Extreme core is necessary to prevent the removal of dentin that immediately supports the gingival enamel. Core is exercised not to prepare the groove directly into axial wall, since no effective retention form is developed and there is risk of pulpal involvement.

Incisal retention cone is prepared with some ¼ bur at axioincisal point angle. It is directed facio-inciso pulpally into the incisal point angle and cut to one half the diameter of bur.

Lingual dovetail – It is required in large preparation.

Prepare the lingual dovetail after preparation of the proximal portion has been completed.

Position the no. 245 in proximal portion at correct depth and angulations and more the bur in a mesial direction. The correct angulation is such that the long axis of the bur is perpendicular to the lingual surface. Move the bur to the point that corresponds to incisal extent of the dovetail. Next more the bur incisally and gingivally to create sufficient incise gingival dimension to the dovetail/25 mm.

Then, prepare the incisal and gingival walls of the esthmus in smooth curvex connecting the dovetant to the proximal outline form.

The gingival marginal trimmer is used to bevel the axiopulpal line angle.

The lingual convergence of the dovetails external walls provide sufficient retention form the retention cones may be placed one in incisal cone and one in gingival corner.

Furnishing External Wall

Remove any unsupported enamel and then smooth enamel walls and margins and refine the cavosurface angles where involicated. The 8-3-22 hoe is recommended for finishing minimally extended margins. If the gingival margin with enamel a slight bevel is necessary to ensure full length enamel rods forming the margin.

Final procedure: Cleaning: inspecting: varnishing same as other cavities.

Class V Cavity Preparation (Fig. 7.15)

- Rubber dam
- Tapering fissure bur no
- No. 2 or 4, ¼ round bur, excavators
- Handpiece
- 7-85-2½ , 6 chisel
- Isolate the site with rubber dam

Initial Cavity Preparation

Using a tapered fissure bur of suitable size enter the carious session to a limited pulpal depth of 0.5 mm from DEJ is 0.75 mm from cementum. When entering a carious lesion, the entry should be off the center of the lesion enough that the bur depth can be related to the original tooth contour. The edge of end of bur is used to penetrate the area to reduce the possibility of burs crawling.

Extend the preparation incisally, gingivallis mesially and distally until all external walls are positioned in sound tooth structure as pulpal depth ranging from 0.75 mm at gingival wall to 1.25 mm (Fig. 7.16) at the incisal wall. The axial wall should be of uniform depth and so should follow the contour of the facial surface of the tooth. Therefore, it should be convex mesiodistally.

The axial wall will be shallower pulpally (0.75 mm) gingival wall that at incisal wall (1-1.25 mm).

This difference in depth increases the thickness of remaining dentin in the gingival aspect of preparation to aid in protecting the pulp.

Final Cavity Preparation

Remove any remaining infected dentin with a no or 24 bur.

Pulp protection is given.

Retention Form

All walls of the cavity preparation diverge outward. Thus, secondary retention must be provided. Using a No. ¼ bur prepare two retention grooves. One directed depthwise most occlusally (slightly pulpally) and along incisoaxial line angle and the other directed depthwise mostly gingivally (slightly pulpally) and along the gingivoaxial line angle.

Alternatively four retention coves at four point angles can be prepared. This is more conservative approach.

Depth of grooves should be 0.25 mm. Care should be taken not to undermine enamel.

Alternate methods of placing grooves is by 7-85. 2 ½ - 6 angle former chisel or no. 33 1/7 bur. Such grooves are angular. But rounded retention is preferred.

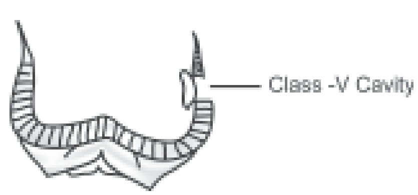


Fig. 7.15: Class-V Cavity

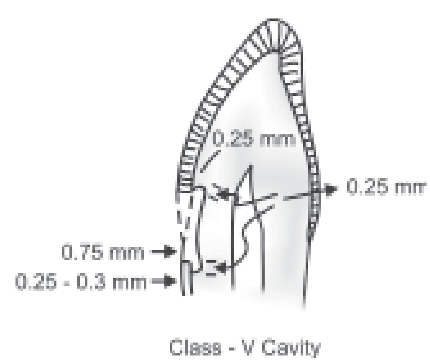


Fig. 7.16: Class-V Cavity preparation

In large preparation, the retention is extended circumferentially along all line angles. Final procedures: cleaning: inspecting: varnishing treatment some as in other cavities.

Extended Cervical Restoration that includes Transitional Line Angles

Caries on the facial surface often extends beyond the transitional line angles of the tooth. If the remainder of the proximal surface is sound, the facial restoration is extended around the angle.

Class VI cavity preparation to restore cusp tips of posterior with amalgam.

Enter the area with a small tapered fissures bur, extending to a sufficient size to place the cavosurface margin on enamel that has sound dentine support. A depth of 1.5 mm is sufficient to provide bulk of material for strength.

Retention is ensured by creation of small undercuts along the internal line angles. Be careful not to undermine enamel.

Complex Amalgam Restorations

Complex restorations involve the use of amalgam restorative material to replace missing tooth structure of teeth severely involved with caries or existing restorative material.

There are preferred over cast restoration in geriatric and debilitated patients, and patients with poor economic status. Also these are indicated in teeth which are to be used as abutment for FPDs (used as foundation). These are used as control restorations in teeth with acute and chronic caries and teeth which are symptomatic positive.

1. Capping Cusps (Fig. 7.17)

When the facial a lingual extension is two thirds for a primary groove toward the cusp tip, reduction of cusp for amalgam capping is mandatory for the development of adequate resistance form.

Reduction should be accomplished early in cavity preparation because it greatly improves access and visibility for subsequent steps. If the cusp to be capped is located the correct occlusal height prior to preparations, make depth cuts (2 mm minimum for functional cusps and 1.5 mm minimum for non-functional cusps). On the remaining surface of each cusp to be capped using the side of a carbide fissure bur or suitable diamond instrument.

These depth cuts act as a guide to provide for uniform reduction of tooth structure. Slightly round any sharp external corners of the cavity preparation formed at the junction of prepared surface to reduce stress concentration in the amalgam and thus improve its resistance to fracture from occlusal forces.

Retention form after cusp reduction is given by retention lock placed in dentine by No. 169 L or ¼ bur. When additional

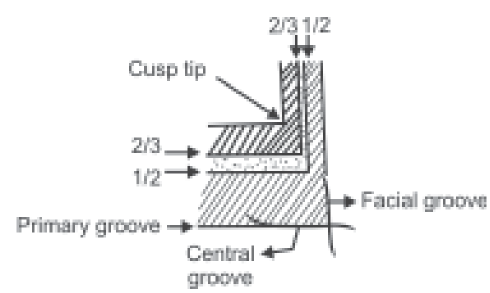


Fig. 7.17: Cusp capping

retention is indicated, slots can be prepared along the gingival floor pulpal to DEJ.

Slot and Lock Retention

For a complete restoration, a slot is a retention groove whose length is in transverse plane and in dentin. A lock is a retention groove whose length in a longitudinal plane and in dentine. These are used in conjunction with pins or as an alternative to it. Slot and lock retention is used more in preparation with longitudinal walls which allow locks to oppose one another pin retention is used more in preparation with few or no longitudinal walls.

A no 33 ½ or no. 169L bur is used to place a continuous slot in the gingival floor. 0.5mm pulpal of dentino enamel junction. It is at level 0.5 mm in depth and 1 or more mm in length depending on the distance between vertical walls.

McMaster has shown that shorter slots provide as much resistance to transverse forces as do longer slots.

Amalgampins (Fig. 7.18)

It was described by shovel several dentine chambers are prepared with the No. 245 bur parallel to the external surface of tooth to a depth of approximately 2 mm. An appropriately sized round bur is used to bevel the junction of pulpal floor and the walls of the chamber to provide additional bulk of amalgam. Amalgam is carefully condensed into the chambers and restoration is completed. The matrix must be to prevent premature sharing of the bulk of amalgam from the dentine chamber prior to matrix removal.

Disadvantages

- Potential for tooth preparation is greater than with slots.
- Retention is not that adequate.

Pin-retained Amalgam Restorations

It may be defined as restoration requiring the placement of one or more pins in the dentine to provide adequate resistance and retention form.

Advantages

1. Conservation of tooth structure.
2. Appointment time – It can be completed in one appointment.
3. Resistance and retention forms are significantly increased.

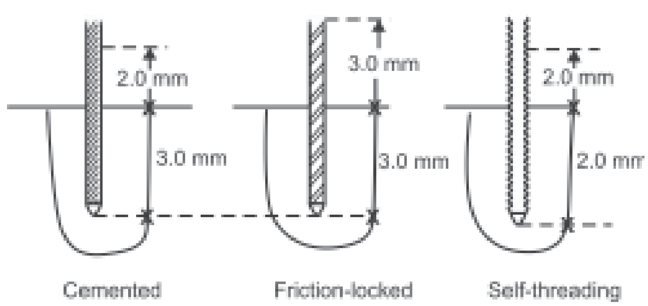


Fig. 7.18: Amalgampins

4. Economics: It is on relatively inexpensive as compared to cast restoration.

Disadvantages

1. Dentinal microfractures: Drilling pin holes and placing pins may create craze lines or fractures as well as internal stresses in dentine such craze lines are important only when minimal dentine is present.
2. Microleakage: around pins occurs. But it is no greater than that occurring at the interface of the restorative material and the cavity walls.

Decreased Strength of Amalgam

This does not reinforce amalgam and therefore does not increase to strength. In fact, tensile strength and transverse strength are significantly decreased.

Resistance Form

It is more difficult to develop than when preparing a tooth for an onlay or a full crown.

Perforations

Pin retention increases the risk of perforating into the pulp or the external tooth surface.

Tooth Anatomy

Proper contours and occlusal contacts are sometimes difficult to achieve.

Type of pins:

1. Self-threading pin
2. Friction lock
3. Cemented pin

Most frequently used pin type is self-threading pin. Friction lock and cemented pins are rarely used.

Self-threading pins: It was described by Young in 1966. The diameter of the prepared pin hole is 0.0015 inch to 0.004 inch smaller than the diameter of the pin. The pin is retained by the threads engaging the dentine as it inserted. The elasticity of the dentin allows insertion of threaded pin into a hole of smaller diameter.

Although the threads of self-threading pins do not engage the dentine for their entire width, the self-threading pin is the most retentive of the three types of pins. It is 3 to 6 times more retentive than the cemented pins.

Disadvantage: Lateral and apical stresses can be generated in the dentine when a self-threading pin is inserted.

Pamerjer and Stalloid have shown that self-threading pins do not create dentinal crazing and that crazing demonstrated in other studies may be caused by technique used for preparation of the specimen.

When the self-threading pin is inserted perpendicular to the pulp, pulpal stress is maximal use of cavity varnish in the pinhole does not reduce the retentive ability of the self-threading pin. The depth of pinhole varies from 1.3 to 2 mm depending on the diameter of pin used.

Several styles of self-threading pins are available. Thread mate system (TMS) is the most widely used self-threading pin because of its:

1. versatility
2. wide range of pin sizes
3. color coding
4. greater retentiveness
5. gold plated pin which reduces the possibility of corrosion.

Cemented pins: It was described by Markley in 1958. In this stainless steel pins are cemented into pinholes prepared 0.001 to

0.002 inch larger than the diameter of the pin. The cementing medium may be either zinc phosphate or polycarboxylate cement.

Friction Locked Pins

In 1966 Goldstein described a technique for the friction locked pin in which the diameter of the prepared pinhole is 0.001 inch smaller than the diameter of the pin. The pins are tapped to place, retained by resiliency of the dentine, and are 2-3 times more retentive than cemented pins.

Pin Retained Class II Amalgam Restorations

Mozer and Walson have pointed the importance of pins as an important adjunct in the restoration of badly decayed or broken teeth.

Initial cavity preparation and final cavity preparation is done similar to conventional, i.e. preparation except the outline is extended to remove all weakened enamel.

After removal of remaining carious dentine the preparation is evaluated for following factors.

1. **Pin Size:** Four sizes of pins are available each with or corresponding color coded drill two determining factors for selecting the appropriate size pin are: (a) amount of dentine available to safely receive the pin. (b) the amount of retention desired. In TMS, pins of choice for severely involved posterior teeth are the minim (0.019 inch 10.48 mm) and the minim (0.11 nm). The minim is too small for adequate retention in posterior teeth. The retention of the pin increases as the diameter of pin increases. Regular (0.78 mm) should not be used as its insertion results in crazing of enamel.
2. **Number of pins:** Several factors must be considered when deciding how many pins are required.
   a. Amount of missing tooth structure.
   b. Amount of dentine available to receive pins safely.
   c. Amount of retention required.
   d. Size of the pins.

Earlier it was advocated one pin per missing cusp and 2 pins per missing marginal ridge should be given (1 pin per missing axial line angle).

Fewest pins should be used to achieve desired retention.

Locations: Several factors aid in locating pinholes:

i. Knowledge of normal pulp anatomy and external tooth contours.
ii. Current radiograph of tooth
iii. Periodontal probe
iv. Patient's age

Caputo and Standlee state that ideally pinholes should be located half-way between the pulp and DEJ or external surface of tooth root. There should be at least 1 mm of sound dentine around the circumference of the pinhole. Such location assures proper stress distribution of occlusal forces.

Felton and others have demonstrated that pin placement allowing at least 1 mm of remaining dentin thickness elicits minimal pulpal inflammatory response.

The pinhole should be positioned no closer than 1 mm to the DEJ and no closer than 1.5 mm to external surface of the tooth.

It is necessary to prepare first a "core" into the vertical wall with a No. 245 bur to permit pinhole preparation as well as to provide as minimum of 0.5 mm clearance around the circumference of the pin for adequate condensation of the amalgam.

Pinholes should be located on flat surface otherwise the drill may slip or crawl.

Whenever three or more pinholes are placed, they should be located at different levels on the tooth if possible. This will prevent stresses resulting from pin placement in the same transverse plane of the tooth.

The optimal interpin distance depends on the size of pin to be used. The minimal interpin distance is 3 mm for Minvein, 5 mm for minim. Maximal interpin distance results in lower level of stress in dentine.

When the pinhole locations have been determined use a No. ¼ bur to prepare a pilot hold approximately one half the diameter of the bur at each location. The purpose of this hold is to allow more accurate placement of the first drill and to prevent the drill from "crawling".

Pinhole Preparation

The Kodex drill should be used for drilling pinholes. The drill is made of a high-speed tool steel that is savaged into an aluminum shank which is color code. The drill shanks for the Miruta and Minkin pins are tapered to provide a built in "wobble" when placed in a latch type contra-angle handpiece. This "too wobble" allows the drills to be "free floating" and thus align itself as the pinhole is prepared to minimize dentinal crazing or breakages of small drills.

Two types of drills are there:

a. Depth limiting for preparing 2 mm deep hole (1.5 mm for Minku).
b. Standard first drills (whose blades are 4-5 mm in length).

Omni-depth gauge can be used to measure accurately the pinhole depth. Place the drill in the gingival crevice opposite the location for the pinhole, position it until it lies flat against the external surface of tooth and then without changing the angulation move the handpiece occlusally and place the drill in the previously prepared pilot hole. Now, view the drill from a position 90 degree to the previous newing position to ascertain that the drill is properly angled.

With handpiece rotating at a very low speed (300 to 500 rpm), apply pressure to the drill and prepare the pinhole in one or two movements until the depth limiting portion of drill is reached.

Using more than one or two movements, tilting the handpiece during the drilling procedure, or allowing the drill to rotate more than very briefly at the bottom of the pinhole will result in a hole that is too large.

The drill should never stop rotating from insertion to removal from the pinhole to prevent the drill from breaking while in the hole.

The mandibular posterior teeth with their lingual crown tilt, teeth that are rotated in the arch, and teeth that are abnormally tilted in the arch deserve careful attention before and during pinhole placement to prevent external perforations and pulpal exposure.

Pin design: 4 designs are available for all sizes (a) standard (b) self-shearing (c) two in one (d) link series (e) link plus.

Link series is contained in color coded plastic sleeve that fit a latch type contra-angle handpiece, or the specially designed plastic hand corench. The pin is fur-floaling which allows it to align itself as is threaded into the pinhole. When the pin reaches the bottom of the hole, the top portion of the pin shears off, leaving a length of pin extending from the dentin. the plastic sleeve is then discarded.

Link plus pins are self-shearing and are available as single or two-in-one pin contained or a color coded plastic sleeve.

This design has a shaper thread, a shoulder stop at 2 mm and a tapered tip to more readily fit the bottom of pinholes as prepared by twist drill. It provides a 2.7 mm length of pin to extend out of dentine. These innovations reduce the stress created in the surrounding dentine and reduce the apical stress at bottom of pinhole.

Standard pin is approximately 7 mm long with flattened head to engage the hand wrench or the appropriate handpiece chuck and is threaded to place until it reaches the bottom of the pinhole as judged by tactile sense.

Its advantage is that it can be reverse one-fourth to one half turn following insertion to full depth to reduce stress created at apical end of the hole.

Self-sharing pin has total length that varies according to the diameter of the pin. It also consists of flattened head to engage the hand wrench or the appropriate handpiece chuck for threading into the pinhole. When the pin approaches the bottom of the hole, the head of the pin shares off, beginning a length of pin extending from dentine.

Two-in-one pin is actually two pins in one with each one being shorter than the standard pin. The two-in-one pin is approximately 95 mm in length and also has a flattened head to and in its insertion. When the pin approaches the bottom of the pin hole, it shares approximately in half.

Pin insertion: Two instruments for insertion of threaded pins are available conventional latch type contra-angle handpiece and TMS hand wrenches.

The latch type handpiece is recommended for the insertion of link series and link plus pin. The hand wrench is recommended for the insertion of standard pins.

When using a latch type handpiece, insert a link series or a link series or a link plus pin into the handpiece and place the pin in the pinhole. Activate the handpiece until the plastic sleeve shears from the pin. Then remove the pin and discard it.

The standard design pin is placed in hand wrench and slowly threaded into the pinhole until a definite resistance is felt when the pin reaches the bottom of the hole. The pin should then be rotated one-fourth to one half turn counterclockwise to reduce dentinal stress created by end of the pin pressing the dentine.

Once the pins are placed, evaluate their length. Any length of pin greater than 2 mm should be removed. Recall that 2 mm of pin length into amalgam is appropriate. Also it is desirable to have at least 2 mm of amalgam over the end of the pin to prevent unnecessary weakening of the restoration.

To cub off the excess length of pin, use at high speed a sharp No. ¼, ½ or 169 L bur oriented perpendicularly to the pin. If oriented otherwise, the rotation of the bur may loosen the pin.

The assistant should apply a steady stream of air to the pin and have the evacuation tip positioned to remove the pin segment.

Test the pin for tightness using the mirror, view the preparation from all directions to determine if any pins need to be bent to position them within the contour of the final restoration and to provide adequate bulk of the amalgam between the pin and the external surface of the final restoration.

Bending may be necessary to allow for condensation of amalgam, occluso-gingivally. When pins require bending, the TMS bending tool must be used.

Cemented pins: Pinholes are prepared in dentine 3 to 4 mm deep using a twist drill with a diameter of 0.68 mm or 0.53 mm.

Threaded stainless steel wire with a diameter of 0.6 mm is used for 0.68 mm pin hole and 0.51 mm wire for 0.53 mm pinhole. The pins are cemented into place with zinc phosphate or polycarboxylate cement using lenticlospiral instrument.

Core : A core is an initial restoration of a severely involved tooth in such a manner that the restorative material will serve in lieu of tooth structure in subsequent procedures for developing the final restoration.

Amalgam restoration (foundational) are the treatment of choice for posterior teeth when sufficient tooth structure remains.

Slots, locks and threaded pins can be used for retention of foundation in vital or root canal heated teeth.

Alternative technique has been described by Nayyar, Walton and Leonard for developing foundation in multi-rooted root canal treated teeth. It is advocated when there is sufficient pulp chamber space and adequate dentine thickness in the region of pulp chamber to provide rigidity and strength to the tooth.

Kane has demonstrated extension onto the root canal when pulp chamber height is 2 mm or less. Natural undercuts and divergent canals provide necessary retention. The amalgam is condensed and foundations are built.

Retrograde Amalgam Restorations

Zinc free amalgam restorations have been used as retrograde restoration after apical resection. Two types of preparation have been made.

Class I and the slot and figure of height type depending on the anatomy of the canal.

Ultrasonic tips are used for the cavity preparation.

Root is first resected at 45 degree angle and the palatal end of the cut is at higher limit than buccal end. This facilitates proper visualization.

A 33 ½ bur or ultrasonic tip is carried down into the canal for a minimum of 1 mm but preferably at least 2-3 mm. The bur should be aligned along the long axis of the tool and remain within the confines if the canal while the preparation is made.

A 33 ½ bur or ultrasonic tip is used and two round but touching preparations are made with care taken to keep the bur along the long axis of the root.

Slot type preparation is advocated in teeth where removal of root structure will lead to an inadequate crown root ratio.

The preparation is made by using a No. 700 bur sloting at the apex of tooth, the bur is brought toward the cervical margin approximately 2 mm leaving a trough of tooth structure missing. Then a no 33 ½ or 35 bur or ultrasonic tip is used to sharpen the corners of the preparation to afford undercut for retention of filling material.

Bonded Amalgam Restorations (Fig. 7.19)

To overcome the shortcomings of amalgam restorations including lack of adhesion to tooth surfaces and microleakage, bonded amalgam restorations have been developed. This technique involves placement of metal adhesive (4th generation bonding agent) to the cavity walls and then condensing silver amalgam over it. The first metal adhesive developed contained.

4 META and had a bond strength of 17.7 Mpa.

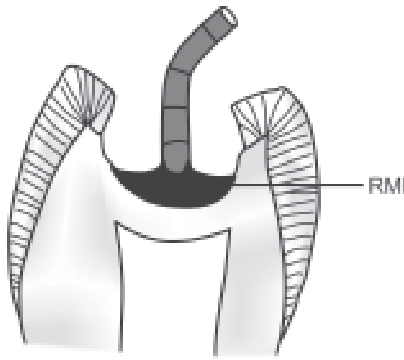


Fig. 7.19: Bonded amalgam

Technique : The conservative type of cavity preparation is done only tooth structure weakened by caries is removed. There is no need for giving extra retentive features like grooves or slots in small preparation. These can be incorporated for larger preparations.

- Etching of the cavity walls is done after application of base or liner (in moderate or deep cavities).
- Etchant is washed off.
- Visibly moist cavity should remain after drying.
- Primer is applied in layers.
- The dentin enamel bonding agent is applied with the brush.
- Amalgam is condensed into the cavity before the auto curing bonding agent is polymerized.

Advantages

1. It permits more conservative cavity preparations.
2. It eliminates the use of retentive pin and their inherent risks.
3. It reduces marginal leakage.
4. It reinforces tooth structure weakened by caries and cavity preparations.

   It reduces the incidence of postoperative sensitivity.

- It reduces the incidence of marginal fracture.
- It reduces the incidence of recurrent caries.
- It allows the biologic sealing of the pulpo-dentinal complete.

Disadvantages

- It is technique sensitive.
- It increases the chair side time.
- It increases the cost of amalgam restoration.
- Long-term clinical performance has not been evaluated.

FAILURES OF AMALGAM RESTORATIONS

Defective : Flow or imperfection.

Failure : Inability to perform or to function properly.

Classification

I. Etiological Classification:
   The failures are:
   i. Due to improper case selection and diagnosis.
   ii. Due to errors in cavity preparation.
   iii. Due to lack of pulpal protection.
   iv. Due to improper choice and use of amalgam.
   v. Due to improper use of dentine pins.
   vi. Due to improper contouring, finishing and polishing.
   vii. Due to defective materials (manufacture defects)

viii. Due to improper postoperative instructions.

II. Postoperative signs and symptoms classification:
   i. Pain
   ii. Fracture of amalgam
   iii. Tarnish and corrosion
   iv. Marginal leakage
   v. Ditching of amalgam
   vi. Amalgam tattoo
   vii. Gingival overhangs
   viii. Faulty contacts and high points
   ix. Marginal ridge incompletely
   x. Amalgam blues
   xi. Secondary caries

Improper Case Selection and Diagnosis

i. *Extent of caries:* Extensive caries especially those involving multiple cusps, marginal ridges and other intercrossing ridges should be properly evaluated for feasibility of amalgam restorations. A cast restoration or full crown may be indicated.

ii. *State of the pulp:*
   a. Radiographic changes in periapical region
   b. Pain and pulp testing
   c. Carious exposure of pulp
   d. Chronic insult of pulp due to traumatic occlusion

iii. Position of tooth in oral cavity:
   The occlusion of the individual should be thoroughly evaluated.
   In many cases, MO is present which gives rise to excessive stress concentration in particular teeth or parts of the teeth. These excessive forces may not be comfortably borne by amalgam. Occlusing teeth should be checked for restorations or prosthesis. For example, ceramic restorations, avoidance of galvanism pain, anterior teeth.

iv. Habits and oral hygiene

v. Perio condition class II and V.

Errors in Cavity Preparation:

i. Instruments and instrumentation
   a. Use of high speed instruments without coolants
   b. Use of speeds between 8000-80000 rpm which is most damaging to the pulp
   c. Use of old worn out burs with excessive force
   d. Use of blunt hand instruments

ii. Defects in cavity design and cavity preparations
   a. Improper extension of the cavity design – excessive conservative design not involving sufficient tooth structure etc.
   b. Failure to remove undermined enamel
   c. Failure to completely excavate caries
   d. Inadequate placement of retentive aids
      - Absence of retentive undercuts
      - Absence of retentive grooves
      - No creation of tables in large restorations
      - Auxillary retentions not provided, e.g: pins
      - Improper design of proximal box
   e. Absence of proper resistance
      - Inadequate depth of pulpal flow
      - Inadequate depth of axial wall
      - Improper cervical floors
      - Failure to round off axiopulpal and internal line angles
      - Presence of soft dentine
      - incorrect width of cavity, e.g: Isthmus
   f. Iatrogenic pulp exposures during preparation
   g. Failure to finish off enamel walls would remove all overhanging enamel

h. Cavosurface bevels given
i. Toileting of cavity with caustic

Lack of Pulpal Protection

a. Failure to use $Ca(OH)_2$ sub-base in very deep cavities
b. Absence of cavity liner in cases where bases are not given
c. Indiscriminate use of ZnPo4 cement without the presence of sub-base
d. Indiscriminate excavation of the affected but not calcified or infected dentin, leading to pulpal exposure.

Improper Choice and Use of Amalgam

a. Use of incorrect type of amalgam for a particular cavity
   E.g. – Use of lathe cut, low strength, low copper coupled with conservative modern cavity preparation
   - failure to use high copper admixed alloy in extensive lesion
b. Failure to use correct Hg-alloy ratio
   - use of faulty dispenser
   - arbitrary proportioning of alloy and Hg
c. Contamination Hg leading to an improper amount of Hg finally being available
d. Failure to follow manufacturers instructions in alloy Hg proportions
e. Failure to recognize the preamalgamated alloy, use of excessive Hg for the same
f. Improper amalgamation/trituration
   - use of inadequate force for trituration
   - use of faulty mortar and pestle, e.g. fracture, smoothening
   - faulty amalgamation
   - inadequate time used for amalgamation instead of the recommended time specified by the manufacturer
   - failure in squeezing out excessive mercury after trituration
   - lack of mulling
   - moisture contamination during mulling (specifically during mulling on the palms)
   - lack of isolation during condensation of amalgam, especially true of zinc containing alloys as it can cause secondary expansion (delayed expansion).

Lateral Errors in Condensation

a. Use of too large increments of alloys at a time
b. Use of too large condenser sizes in the initial stages of condensation especially in areas of the internal line and point angles
c. Improper shape selection of condensers for condensation of a particular area in the cavity
d. Use of inadequate condensation pressure (normal condensation pressure = 5 to 7 pounds)
e. Improper use of angulations of condensers head as related to the type of alloy being condensed (lathe cut alloy condensed at the angle of 45 degrees spherical alloy at the angle of 90 degrees.
f. Failure to bring excessive mercury to the surface in between successive layers of amalgam to prevent layering of amalgam
g. Presence of voids in the amalgam due to improper condensation which can reduce the strength upto 50%
h. Condensation less than the required amount of amalgam.

Improper Use of Dentine Pins

a. Number of pins
b. Placement of pins
c. Size of pins
d. Depth of the pins in and out of dentin

e. Iatrogenic perforation
f. Pulp exposures
g. Dentin crazing
h. Fracture of pins
i. Improperly retained pins

Improper Contouring, Finishing and Polishing

a. Improper use of matrix and wedge:
   - use of improper retainer
   - use of too large or too small bands
   - failure to separate teeth prior to and during restoration procedures
   - failure on the part of operator to contour the matrix band
   - use of improper material of matrix band, e.g. plastic band
   - failure to use a wedge
b. Improper carving
   - Failure to carve cuspal anatomy
   - Improper flushing of margins
   - Development of improper contacts and occlusion plane leading to excessive occlusal forces in the particular areas of restoration which may lead to fracture
   - Gingival over hanging
   - Improper carving of marginal ridge
   - Over or under contouring of contact areas
   - Absence of contact points
   - Defective axial contouring, e.g. buccal/lingual cusps
c. Improper finishing and polishing
   - Failure to wait for adequate time before polishing
   - Failure to polish the filling causing
     - Tarnish and corrosion
     - Mercuroscopic expansion
     - Increase chances of galvanism
     - Plaque accumulation
     - Gingival initiation
     - Marginal ditching if flash not removed.

Defective Material

Manufacturer error:
a. Failure to maintain particle size
b. Improper heat treatment
c. Improper proportion of components
d. Improper packaging
e. Failure to state exact nature of alloy powder
   E.g. Zinc containing, zinc free alloys, mercury alloy ratio.

8A Comparison of Composites and Glass Ionomer

Development of Composites

In an effort to improve the physical characteristics of unfilled acrylic resins, Bowen of the National Bureau of standards developed a polymeric dental restorative material reinforced with silica practical.

The introduction of this filled resin material in 1962 became the basis for restorations that are termed composites.

They basically consist of a mixture of a dispersed phase of filler particles that are distributed within a continuous phase (matrix phase).

Looking down the ages, we saw that the early attempts at esthetic filling materials which were aimed at acrylic resin and composites were based on silicate cements. However, solubility problems with these materials led to the introduction of unfilled acrylic system based on polymethyl with acrylate (PMMA) but it was seen that the methyl methe acrylate ionomer contracted excessively during polymerization, permitting subsequent marginal leakage. Also, PMMA was not strong enough to support occlusal loads. Therefore, reinforcing ceramics fillers, principally containing silica were added. Changing the original unfilled acrylics into filled acrylics.

Development of Glass Ionomer Cement

The design of the original glass ionomer cements was a hybrid formulation of silicate and polycarboxylate cements. Glass ionomers used the aluminosilicate powder from silicates and the polyacrylic acid liquid of polycarboxy takes the earliest commercial product was named using the acronym for this hybrid formulation and was called ASPA (alumino silicate polyacrylic acid).

Wilson Kent (1972) was the pioneer who first laid down this formulation and ever since then research has been going on to improve glass ionomer products to the point of being competitive with other restorative materials.

Comparing the Composition of the Materials

Dental composite has traditionally indicated a mixture of silicate glass particles with an acrylic monomer that is polymerized during the application. The silicate particles provide mechanical reinforcement of the mixture (reinforcing fillers) produce light transmissions and light scattering that add enamel like translucency to the mixture. The acrylic monomers make the initial mixture fluid and mouldable for the placement into a cavity preparation. The matrix flows to adapt to cavity preparation walls a penetrates into micro-mechanical spaces on etched enamel or dentin surfaces.

Because the flow of uncured composites is quite limited, most manufacturers provide a bonding system, which is primarily an unfilled acrylic monomer mixture that is prepared onto conditioned (etched) tooth surfaces to form a 1 to 5 mm film its micro-mechanically interlocks with the etched surfaces, seals the walls of the preparation and co-polymerizes with the composites that fills the cavity preparation. The fillers consist of silicate glass and barium, zinc and yttrium are the most popular fillers, also used are colloidal silica or ground quartz. The matrix consists of BIS-GMA or UDM (bis phenol A-glycidyl methacrylate or urethane meth acrylate) but these are extremely viscous need to be diluted with another monomer of much lower viscosity as TEGDMA (triethylene glycol dimeth acrylate). To provide interfacial bonding between the phases, silica particles are pre-coated with mono-molecular films of silane coupling agents. These are disfunctional molecules, whose one end is capable of bonding to hydroxyl groups present on the silica particles and the other and co-polymerizes with double bonds of monomers in the matrix phase, e.g. v-methacryloxy propyl trimethoxy silane. At present composites are classified based upon their composition and range of near particle size of the major filler as:

i. Conventional/traditional/microfilled
   Filler quartz/borosilicate
   Size – 8-12 mm
   Filler content – 70-80 wt%
ii. Microfilled
   Fillers: Prepolymerized particles of filler, that are splintered and added to the resin matrix.
   Size: 04-4 mm
   Filler content : 35-60 wt%
iii. Hybrid
   Filler—ground filler with microfillers.
   Size: .6-1.0 mm
   Filler content: 75-80 wt%
iv. Small particle
   Size: 1-5 mm
   Filler content: 80-90 wt%

Apart from these major components, an activator initiator system and an inhibitor is also added to enhance the material.

Composition of Glass Ionomers or Chemistry

These consist of ion-crosslinked polymer matrices surrounding glass reinforcing filler particles. The material was based on a solution of polyacrylic acid liquid that was mixed with a complex alumino-silicate powder containing calcium and fluoride. The acidic liquid solution dissolved portions of the periphery of the silicate glass particles to release calcium, aluminium, fluoride and silicon ions. Divalent calcium ions were quickly chelated by ionized carboxyl side groups present on the polyacrylic acid polymer chains crosslinking the chains and producing an amorphous polymer gel during the next 24 to 72 hours, the calcium ions were replaced by more slowly reacting aluminium ions to produce a stronger highly crosslinked matrix.

Comparison of Properties

i. *Modulus of elasticity*: This represents the amount of strain produced in response to stress.
   The material should be generally very stiff so that under load, its elastic deformation will be extremely small.

The modulus of elasticity for the hybrid composites in 13,800 MN/m^2 as compared to the low value of 4000 MN/m^2 for glass ionomers. This low value of glass ionomers is helpful especially in the restoration of the cervical eroded areas of teeth where there is a tendency for the tooth to flex.

ii. Linear co-efficient of thermal comparison

Different restorative materials have different types and number of bonds. During temperature changes they respond differently. During temperature rise, more rapid atomic motions stretch bonds, produce net expansion. During fall in temperature contraction results. The LCTE of tooth structure is 9-11 ppm/^oC. It is important that the LCTE of a restorative material is as near tooth structure as possible to avoid the deleterious consequence of percolation. Glass ionomers are superior in this aspect as compared to composites have a LCTE of 20-25 ppm/^0C, 31 and 26 ppm/^0C for GIC, traditional and hybrid composites respectively.

iii. Bond strengths

Enamel/EBS/composite—18-22 MPa
Dentin/DBS/composite—22-35 MPa
For Glass Ionomers
Enamel/NOSL/traditional glass ionomer—8-12 MPa
Dentin/SL/traditional glass ionomer–6 MPa
Dentin/NOSL/light cured hybrid glass ionomer—10-12 MPa

iv. Diametral tensile strength

Composites (hybrid) – 60 MPa
Glass ionomers – 36 MPa

v. Compressive strength

Composites traditional—236 MN/m^2
Hybrid—455 MN/m^2
Glass ionomers—214 MN/m^2

Comparison of the Mechanism of Bonding

Adhesion of conventional glass ionomers to enamel and/or dentin only produces bond strength in the range of 6 to 12 MPa. By comparison dentin bonding agents can now produce bond strengths of 22 to 35 MPa. Most glass ionomers are aqueous systems (before setting) that wet tooth structure very well because they are hydrophillic. However, glass ionomers tend to have relatively high viscosities and therefore do not flow and adapt to micromechanical spaces very readily.

In contrast, bonding agents are hydrophobic but have been formulated for use with hydrophillic primers to facilitate wetting, flow, and bonding.

Bonding by glass ionomers is achieved in part by mechanical retention and in part by chemical chelation. It is seen that the bond density per unit area of retentive interface is actually higher for mechanical bonding than for chemical bonding. Excellent bonding cannot be achieved by chemical bonding along. In most cases, good mechanical bonding is much more important than chemical bonding. Thus, the potential of glass ionomers for chemical bonding is only an advantage in situations where it is difficult or impossible to produce micro-mechanical retention.

Composites on the other hand rely solely on micro-mechanical bonding by making using of enamel and dentin bonding systems. Enamel bonding systems consist of an unfilled liquid acrylic monomer mixture placed onto acid etched or conditioned enamel. The monomer flows into interstices between and within enamel rods.

Enamel bonding depends on resin tags becoming interlocked with the surface irregularities created by etching. Resin tags which form between enamel rod peripheries are called nacrotags, and the much finer network of thousands of smaller tags which form across the end of each rod, where individual hydroxyapatite crystals have been dissolved having crypts outlined by residual organic natural are called microtags.

Macrotags and microtags are the basis for micromechanical bonding. Microtags are more important because of their large number and great surface area of contact. The bonding agent co-polymerizes on its other side with the matrix phase of dental composite, producing strong chemical bonding. The bond strength of such a joint is 18 to 22 MPa.

The dentin bonding systems involve an unfilled, liquid acrylic monomer mixture which is placed onto an acid conditioned and primed dentin surface.

The bonding primer consists of hydrophilic monomers such as 2-HEMA which can wet dentin surfaces. Although primes and/or bonding agent may flow into dentinal tubules, the bond strength is primarily related to micromechanical bonding to the inter tubular dentin which occurs between tubules along the cut dentin surface.

These coupled with hydrophilic primers, bond strength increased to 22 to 35 MPa.

Biological Properties

Anticariogenic Property

Fluoride release from glass ionomer is diffusion limited and affected by the concentrations in both the matrix and the particles. The initial high burst of fluoride release is due to the high concentration of fluoride that exists in the matrix immediately after the setting reaction is complete.

During the initial acid dissolution of powder particles edges, a large amount of fluoride becomes part of the reaction product matrix. This fluoride diffuses quickly from the matrix exposed on the surface of the material and is only slowly replaced by fluoride diffusing from greater distances in the matrix below the surface or by fluoride diffusing from the particles into the matrix for the first line. Therefore, the long-term release of fluoride is at much lower rates.

As evidence indicates little or no secondary caries associated with fluoride containing silicate cements, inspite of significant marginal disintegration during restoration solubilization, the same success was expected with the glass ionomers. However, there are 2 points which limit the influence of ion release.

Firstly fluoride ion release is proportional to the concentration which can diffuse from the matrix and/or residual silicate particles through the restoration surface. Generally, there is relatively high fluoride ion release during the first few days but the rate of release falls as a concentration gradient develops within the outer layers of the glass ionomer.

The second point is that absence of significant secondary caries is not evidence of a fluoride ion effect.

Composites also release fluorides, which are either incorporated within the matrix or as fluoride releasing filler systems. Fluoride is released over a prolonged period and both enamel and dentin take up a large proportion of the released fluoride and thus results in inhibition of secondary caries. Materials as heliomolar RO, tetric ceram and tetric flow continue to release fluoride.

Comparison of Biocompatibility

Traditionally glass ionomers have caused concern clinically. They are very acidic at the time of mixing initially and have the potential to produce postoperative sensitivity and pulpal irritation. As the reaction proceeds, the pH increases from initial values near 1.0 to the range of 4 to 5. As the setting reaction nears completion the final pH value reaches 6.7 to 7. Because the acid groups are attached to polymer molecules which have limited diffusability the potential pulpal effects of low initial pH are limited to areas immediately adjacent to the material. If the remaining dentin thickness is less than 0.5 mm, it is very important to protect dentin surfaces from direct contract with unset materials by using $Ca(OH)_2$ liner.

When fluid filled dentinal tubules are in direct contact with selling cement, two problems occur. High ionic concentration in the unset glass ionomer causes dentinal fluid to rapidly diffuse outward into the cement, producing a pulpal pressure change and creating pulpal sensitivity or pain.

At the same time, unset components, such as hydrogen ions, may move into tubules or towards the pulp. This may cause chemical irritation when there is inadequate remaining dentin thickness with tubule fluid contents that tend to buffer the acid before it can diffuse to the pulp.

Biocompatibility with reference to composites is mainly due to the unpolymerized materials which are potentially cytotoxic and may even be classified as carcinogenic, although they are very poorly soluble in water and are polymerized into a bound state before there is significant time for dissolution and diffusion. Monomers which do not polymerize may diffuse slowly out of the restoration, but the concentration at any given time is so low that the materials do not appear to represent any practical risk.

In cases of deep cavities pulp protection may be afforded by using either $Ca(OH)_2$ liner or base or an glass ionomer liner as a "sandwich". The advantages of using this technique are as follows:

i. the glass ionomer material bonds both to the tooth structure and the composite thereby increasing retention form;
ii. fluoride contained in the glass ionomer material reduces the potential of recurrent caries;
iii. the glass ionomer material, because of its bond to tooth structure, provides a better seal when used at non-enamel margins.

Comparing the Modifications made in the Materials

A variety of compositions and changes in the evolution of glass ionomer materials has taken place which are as follows:

1. Traditional glass ionomers (liners, bases cements)
   a. modifications by adding co-monomers to polyacrylic acid.
   b. Smaller powder particle size
   c. Experimentation with dehydrated liquid component
2. Metal modified glass ionomes (filling materials, bases, cores):
   a. miracle mixtures (with amalgam alloy admixed with cement)
   b. cernet particle re-inforcement
3. Light cured glass ionomers (liners, bases):
   a. HEMA added to liquid component polymers in liquid modified with acrylic functional groups.
   b. Other powder particles mixed with alumino silicate glass.
4. Hybrid (resin modified) glass ionomers : (cements, restorative filling materials, cores)
   a. HEMA and other polymers added to the liquid component.

b. Polymers and other phases added to the powder component.
c. Silicate glass of composites substituted for some of the powder.
d. Pre-cured glass ionomer blended into composites.

The resins modified glass ionomers are a heterogeneous group, that contains precured particles of cement admixed with the primary composition. The biocompatibility of these materials also appears to be much improved over conventional formulations.

The light cured resin modified glass ionomers represent the tri-cure materials, where in apart from the acid base and light cure reaction the material also undergoes self-cure.

E.g. 3 M Vitrebond: Its features include:

- Light cure for faster cure and immediate finishing options
- Dark cure chemistry allows bulk placement
- Excellent fluoride release
- Ability to resist secondary decay
- Ideal for pediatric and geriatric patients
- Assessment of shades for perfect tooth match.

The modifications incorporated into composites are aimed at combining it with other materials such as glass ionomers or ceramics to take advantage of their properties.

Amongst these are ceromers and compomers.

Ceromers consists of ceramic optimized polymers which combine the advantages of ceramics and composites. These consist of specially developed and conditioned fine particle ceramic fillers of submicron size (.04-1.0 hm) which are packed closely and embedded in an advanced organic polymer matrix.

Compomers

This material combines attributes of glass ionomers and composites. It chemically bonds to tooth structures similar to glass ionomers and has the esthetics of composites.

Moreover, like the glass ionomers it has also been reported that it releases fluoride over a long period.

Clinical Placement of the Material

With development in the properties of the two materials cavity preparation to receive these materials need not be convention.

Due to their limited strength and wear resistance, glass ionomers are indicated generally for the restoration of low stress areas (not for typical class I, II or IV cavities) where caries actually potential is of significant concern. In addition glass ionomers are indicated for root surface caries in class V locations, slot like preparations in either class II and III cervical locations (not involving the proximal contact).

Insertion of the Material

With the exception of the matrix utilized (if needed) slot type preparations for classes II and III cavities are restored in a similar manner to class V preparations.

In deep excavated areas (within 0.5 mm of pulp) $Ca(OH)_2$ liner/base is given, followed by conditioning of dentin with a mild acid as 10% polyacrylic acid for 20 seconds, followed by rinsing and drying with clear, dry air. Powder liquid are mixed quickly shaped with an instrument. A cervical matrix can provide contour and if a conventional type of glass ionomer is used, place a thin coat of resin bonding agent on the surface immediately after placement to prevent dehydration and cracking of the restoration during initial setting phase. If a light cured glass ionomer is used, cure for a minimum line of 40 seconds.

Contouring and Finishing

Conventional versions of glass ionomers ideally require a polymerization period of 24 hours before final contouring and finishing. Most light cured, present now can be contoured and finished immediately after light curing once set, the matrix, if used, is removed and gross excess is shaved away with either a No. 12 surgical blade or appropriately shaped knives or scalers. As much as possible of the contouring refinishing should be one with hand instruments while trying to preserve the smooth surface that occurs upon setting.

If rotary instrumentation is needed, care is taken not to dehydrate the surface of the restoration micron finishing diamonds used with a petroleum lubricant to prevent dissication are ideal for contouring and finishing.

Also, flexible abrasive discs used with a lubricant can be very effective. A fine grit aluminium oxide polishing paste applied to impart a smooth surface.

Composites are materials primarily given in cases where esthetics is of prime concern and the area is a relatively non-stress bearing area.

The cavity preparation followed for a composite restoration is a minimal invasive cavity. Though conventional cavity preparation and beveled conventional types are not in much use, modified preparations are done, wherein only the pathology is removed, bevel is placed and in cavities pulp protection is given.

Following this the cavities are acid etched, prined and conditioned and bonding agent is applied self-cured materials can be inserted by hand instruments or syringe injection. Light cured materials can also be inserted similarly. Initial gross reduction is carried out by carbide finishing burs or green stones or coarse aluminum disks coarse diamonds are generally not recommended as they leave a rough surface on the restoration and tooth is compared to finishing burs and disiss.

Final finishing is done with fine silicon carbide or aluminum oxide disks or white Arkansas stone rubber polishing points and aluminum oxide polishing pastes can also be used for proximal and embrasure areas, a shared gold finishing knife is used to remove the excess and esthetic trimmers and carbide carvers are used for finishing.

Final contouring and finishing of proximal surfaces is completed with finishing strips, of which medium grit is of zirconium silicate and fine grit is of aluminum oxide.

Life of a composite restoration ranges from about 10-15 years provided meticulous attention has been paid in the procedure which includes, complete isolation of the cavity thus avoiding any contamination of the field during the entire procedure, proper acid etching, washing and drying, placing of the primer and bonding agent, incremental build up of the material in increments being not more than 2 mm each. This ensures complete polymerization. The tip of the source of light from the material should not be more than 2 mm and the frequency of the light should be checked regularly as it affects the degree of cure. Other factors as the use of reflective wedges help to direct the polymerization shrinkage towards the margin rather than away from it.

With the glass ionomers, their clinical age is less than 10 years with surface discoloration being the most common reason for a replacement.

The factors which contribute to a good restoration include, proper isolation followed by conditioning of the cavity to remove the smear layer and enhance union, immediate protection of the material from moisture contamination after placement as it leads to water absorption and dissolution of the cement. Moreover, dry air result in desiccation and crazing or cracking the cement.

Thus it should be protected by a matrix during its initial set, followed by varnish or unfilled acrylic resin after matrix removal. Finishing should be delayed for 24 hours after which the restoration should be protected again.

8B Recent Advances in GIC and Composites

INTRODUCTION

A new era in dental restorative materials began in 1955, when Buonocore found that acrylic resin formed acceptable micro-mechanical adhesion with dry enamel that had been etched with phosphoric acid. Many generations of restorative materials have existed is the last 5 decades, and the molars clinician may be overwhelmed when attempting to make decisions as to which material or technique would be most appropriate in varying clinical situations.

In the current age of adhesive dentistry or microdentistry, conservation of tooth structure is paramount. Rather than using "extension for prevention" as a treatment guideline, emphasis is now placed on "restriction with conviction".

This seminar aims at discussing recent advances is glass ionomers and composites which have revolutionized the field of dentistry.

RECENT ADVANCES IN GIC

Traditionally three types of GIC are available based on their formulations and their potential uses.

Type I	-	Cutting applications
Type II	-	Restorative material
Type III	-	Liner or base
Type IV	-	Core build ups

Over the years various advancements have been the following:

Metal Modified GIC

1. Silver alloy admix
   In this there is mixing of spherical silver amalgam alloy powder with the type II glass ionomer powder.
2. Cement
   This system involves fusing glass powder to silver partices through high temperature sintering of a mixture of two powders.

Packable GI

Some glass ionomer formulations with increased powder to liquid ratios have been developed, which serve as excellent long-term temporary restorations and as permanent restorations in austere clinical conditions or harsh oral environments caused by radiation, medications and autoimmune diseases.

Resin Modified GI

Triple Cure

Five percent dual cure resin was added. This allowed light curing and rapid clinical set.

Chemically the resin portion of these materials sets rapidly through light curing, but the acid-base reaction of glass ionomer still occurs, although it is delayed.

Resin-reinforced Glass Ionomers (RRGI)

This development led to modification of the fluoroalumino silicate glass particles to decrease particle size and develop multiples shades.

Compomers/Polyacid Modified Composite Resin

These materials are composites that have been modified by the addition of a portion of filler particles or an acid polymer normally found in conventional glass ionomers.

Flowable Compomers

Currently appearing on the market, which have similar inferior properties as other flowable composites when compared with conventional microfill and hybrid composites.

ADVANCEMENTS IN COMPOSITES

Resin Matrix

Most composite materials are based on arometic or aliphatic diacrylater such as BISGMA, urethane dimethacrylete (UDMA), triethylene glycol-diethacrylate (TEGDMA).

Their disadvantage is their viscosity at room temperature. The use of diluert monomers like TEGDMA has significantly reduced viscosity.

Other materials which have been tried are methylene butyrolactone monomer (cyclic analogue of methyl/methocrylate).

Recently sphero-ortho-carbonates have been developed. They expand during polymerization. These along with 3 component epoxy constitute the resin matrix.

Advantages

- Increased mechanical properties
- Improved water sorption, solubility
- Less polymerization shrinkage

Filler

The amount and size of filler particles determine the type and ultimately the most advantages clinical application of each composite.

Types of composite based on filler size

Composite	*filler size*
Megafill	0.5-2.0 mm
Macrofill	10-100 um
Midifill	1-10 um
Minifill	0.1-1.0 um
Microfill	0.01-0.1 um
Nanofill	0.005-0.01 um

Macrofilled Composites

- First type of dental composite to be developed in 1960’s.
- Filler content is 70-80% by weight.
- Volume % is 10-15% lower.
- Physical properties are determined by volume %.
- Large size of filler particles results in a restoration that feels rough to explorer and to eye as well.
- Therefore, likelihood of plaque accumulation and staining is more.
- Little clinical importance nowadays.

The inorganic fillers mainly influence the properties, and therefore they are the basis of the modified classification.

For inorganic filler types should be considered with regard to contemporary composites.

- Pyrogenic silicon dioxide, average particle size between 0.002 and 0.004 mm.

- Microfine barium or strasstium – silicate glass.
- Fine ground quartz.
- Zirconium – dioxide glass
- Ythrium or ytterbium – trifluoride.

Microfilled Composites

Contain only pyrogenic silicon dioxide.

Type I—Pyrogenic silicon dioxide is the resin matrix as well as is a splister polymer.

Type II—Pyrogenic silicon dioxide as well as larger agglomerates of pyrogenic silicon dioxide, but no organic fillers in the resin matrix.

Hybrid Composites

Contain different types of inorganic fillers.

Type I —Filled with a blend of pyrogenic silicon dioxide (upto 15% by wt) and microfine glass (barium stratium silicate or zirconium dioxide glass, upto 80% by wt) or fine ground quartz (upto 60% by wt).

Type II —Contain a blend of pyrogenic silicon dioxide (upto 40% by wt) and of yttrium or ytterbium trifluoride (upto 40% by wt.) but no microfine glass.

Microfilled composites have advantages of high polish that lasts in addition to excellent esthetics. The volume-to-surface area ratio of microfills is such that a great amount of resin is needed to wet the filler particles, however, so that the amount of fill is low (40 to 50% by weight). A more accurate description of fill amount is by percent fill by volume, which is usually 15 to 20% less fill than by weight (e.g. Dwafill).

Hybrids (e.g. Charisme F)

Hybrids are a combination of microfill and larger filler particles.

Disadvantage

Difficulty in long-term maintenance of a high polish.

Advantages

- Strength
- High percent fill (75 to 80% by wt)
- Wide array of shades of varying opacity, translucency, dentin replacement.

Optimal Size Particle (e.g. Esthet-X)

One new type of composites currently appearing on the market attempts to use the optimal size particle that is small enough to polish similar to a microfill but large enough to be highly filled. This type of composite has created a new class of hybrids that rival microfills for esthetics and are as highly filled and have physical properties equal to hybrids.

Composites Surface Sealants

The finishing process leaves surface defects and microcracks that may propagate over time and acclerate breakdown and wear. Use of a surface sealant has been shown to restore and maintain surface luster and to decrease wear significantly over time.

Flowable Composites

Since 1995, a new type of composite described as flowable has become popular.

To make a composite of low viscosity or flowable, two processes must be accomplished:

(i) Particles size is increased
(ii) Filler amount is decreased

Compared with microfills and hybrids, they are less sticky and advertised to have exceptional handling properties. They are significantly less filled than microfills.

Manufacturer claim their following uses:

- Restoration of all tooth surfaces
- All classes of restorations
- Direct veneers
- Core build ups

When compared with microfills and hybrids, the CTE, wear rate, and surface roughness all would be significantly higher for flowables, whereas the physical properties would be drastically inferior.

Condensable Composites

Also called packable composites.

These restoratives are marketed as composites that pack, carve and handle similar to amalgam as well as being able to be light cured in bulk up to 5 mm in depth. Despite manufacturers claims, incremental addition and light curing of each layer is essential with all composite restorations.

Generally have larger than average filler particles, and resin matrix is modified chemically to allow slight increase is filler amount. These materials, if handled properly, have comparatively excellent physical properties, but they are marketed in fewer shades, inferior esthetic compared with hybrids, and poor surface finish. Handling also is difficult.

Indirect Composites

In clinical situations where considerable tooth structure has been lost and preparation requires restoration within esthetic material and a direct composite is not possible, indirect composite may be as excellent choice.

Advantages

- Minimal wear of opposing teeth
- Ability to be characterized in lab
- Repairability with hybrid composites

Compared with hybrid composites, physical properties are much higher as a result of polymerization conditions that increase the degree of conversion to nearly 100%.

Clinically, occlusal and contour adjustment, polish, and cementation are easier to carry out when indirect composites are compared with metal or porcelain restorations.

Fiber Reinforced Indirect Composites

When high flexural strength is desired, and indirect composite in restoration of choice, the use of polyethylene or glass fibers incorporated is the composite core before curing result in materials termed fiber reinforced indirect composites.

They are popular in situations in which conventional indirect composite or porcelain is not indicated, yet the patient demands a metal-free restoration.

Composite Resin Cements

When luting a tooth colored restoration, whether it is an indirect composite, fiber reinforced indirect composite or porcelain, the cement must contribute significantly to the overall retention through adhesion.

These cements are composite resins. They are filled to a lesser degree than hybrids to facilitate handling properties. They may approximate properties of flowable composites.

These systems commonly are light cured, a mode that is used when, cementing this indirect composite or porcelain veneers. When seating inlays, onlays, and crowns, the catalyst is mixed is to ensure cure in areas not reached by light.

Core Buildup Composites

Because of their tooth color, ability to bond to tooth, and ability to allow preparation in the same appointment, composite core materials are used extensively. These materials are marketed in light core, dual core and self-cure systems.

These may be incompatibility of many adhesives with some of the core materials.

Composite resins containing silica fused ceramic single crystalline

Whiskers (Under Trial)

Silicon nitride whiskers, with a diameter 0.4 um and length 5.0 um have been

- Silarized and then used as filler
- Mixed with silica glass particles, silarized and then used as filler.
- Fused with silica glass at high temperature, silarized and then used as filler.

Advantages

- Significantly higher flexural strength than conventional composites
- Increased modulus of elasticity
- Increased hardness
- Increased resistance to crack propagation
- Increased resistance to contact damage
- Although size of whiskers is small, strength of whiskers is about 10 times that of fibers reinforced composites

Calcium Phosphate Composites

Scientists are working on combining calcium phosphate with resin matrices for new restorative material. Calcium phosphate reacts with hydroxyapatite.

Physical Properties of Ormocers

Bending strength	100-160 MPa
Modulus of elasticity	10-17 gPa
Coefficient of thermal expansion	$17\text{-}25 \times 10^{-6}K^{-1}$
Water uptake	< 1.2 %
Solubility in water	not detectable
Shrinkage	1.7-2.5 vol%

Polymerized but still under trial.

Ormocers:

- Organically modified ceramics
- Basically composites with matrix of ceramic polysiloxare.

Advantages

- Biocompatible
- Highly esthetic
- Reduced polymerization shrinkage

Some material properties of composites and compomers

Properties	*Compomers*	*Composites*	
		Microfiller	*Hybrid*
Flexural strength MPa	90-120	40-70	100-140
Compressive strength MPa	200-300	400-500	350-450
Modulus of elasticity Gpa	5-9	2.4-3.5	8-20
Polymerization shrinkage Vol	3	3	1.5-3
Radiopacity	Very good	None	Very good
Polishability	Satisfactory	Very good	Good
Wear compared with amalgam	Greater	Greater	Smaller-greater

- Safe and fast handling
- High abrasion resistance.

Smart Composites

In basic term smart composite involve embedding micron size sensor particles into a composite product during its normal manufacturing process. The embedded sensors or 'tag' interact with their host structures and generate quantifiable signatures when interrogated by special instrumentation.

This class of composites was introduced as the product Ariston PHC is 1998, is an ion-releasing composite material. It releases fluoride, hydroxyl which causes the pH drop in the area immediately adjacent to the restorative material.

Smart composites activity is based on the new alkaline glass filler which will reduce secondary caries formation at the restoration by inhibiting bacterial growth. This results in a reduced demineralization and buffling of the acid produced by caries forming microorganisms.

The paste consists of Ba, Al and F silicate glass filler (1 um) with ytterbium silicon-dioxide and alkaline calcium silicate glass (1.6 um) is dimethacrylate molecule filled 80% by wt. and 60% by volume. Use of an adhesive is recommended. However, dentin should be sealed to reduce sensitivity.

Ceromers (e.g. Tetric Ceram)

- Ceramic optimized polymers
- Consists of barium glass (< 1 um), speridal mixed oxide, ytterbium trifluoride, and silicone is dimethacrylate monomers – BIS-GMA and UDMA by a polymerization of C=C of the methacrylate. They must be bonded to tooth structure.
- Properties are identical to those of composites.

8C Biologic Considerations in Restorative Procedures

Structurally the tooth consists of a pulp organ composed of cells, blood vessels, lymphatics and nerves. This is surrounded by a calcified layer called dentin. The dentin has odontoblastic processes that extend from the peripheral layers of the pulp into the dentinal tubules. Coronal to the dentin is the enamel which is superficial layer of aratomical crown. In the root portion the dentin is covered by cementum.

The tooth is suspended in the alveolar bone by means of periodontal ligament fibres and the entire tooth is collapsed by gingival soft tissue. To restore a tooth to health from function and esthetics it is important to have a knowledge and understanding of all this associated structure and their physiology.

Knowledge about the usual anatomy of the pulp chamber and canals is an essential factor in selection of the restorative material and procedure.

Enamel: It is the protective layer and is the hardest substance in the body. Its physical structure and hardness are protective to underlying dentin and pulp during function.

The enamel has a hardness of 343 KHN compared to 68 KHN of dentin so it is 5-20 times more resistant to abrasion. But this properly makes the enamel more brittle especially when it is not supported by dentin.

The enamel structurally consists of enamel rods, rod sheaths and interprismatic substance.

The structure of enamel is very important consideration in cavity design as the success of many restorative procedures depends on the integrity of enamel. The enamel rod shows varying angulation on the surface. So the walls of the cavity are designed in such a manner that all margins are supported by dentin. Any area left unsupported tend to fracture due to its brittleness. Such a defect can act as a recover of plaque and can recurrent caries.

Occlusal Enamel Wall Design

For many restorative materials including amalgam the walls should be parallel to the direction of the enamel rods without any unsupported enamel. When the principle is followed by cavity wall angulation can vary from convergent to divergence in such parallel in depending on the buccolingual walls of the prepared cavity.

Cavity preparation extending not more than ¼-1/3rd of the intercuspal distance and having any one type of walls will have supported enamel at the cavosurface margins. But when the preparation width is ½ or more of the interecuspal distance the cavity walls require more occlusal divergence to achieve this principle. This is the basis behind concept of topic in inlay preparation. The integrity of the enamel at the cavosurface is tested clinically using a sharp chisel or hatchet with moderate force.

So the angulation of the cavity walls is deendent on the intercuspal width of the cavity which in turn is greatly influceced by degree of tooth structure lost and the material to be used.

Certain materials require beveled cavosurface angle. Bevelling is based on the angle of cuspal incline.

Proximal Enamel Wall Design

In the proximal box also the cavity wall should be made parallel to the direction of enamel rods. Enamel rods in the cervical portion can be directed occlusally, apically or horizontally depending on the area between the occlusal surface and the CEJ.

In case of proximal cavity preparation the amalgam enamel hatched or GMT is used a plane the gingival wall perpendicular to the external surface or slightly apical. Bevels are placed in the gingival wall for cast restoration ensure adequately supported enamel.

When box shape cavity is used the buccal and lingual proximal wall should form 90 degree butt joint with the tooth surface.

This design can be modified for certain restorative material to obtain are convenience form. This modification can be slicing beveling or enhancing or enhancing flares as in cast gold margins.

Class 5 designs: In this cavity preparation the cavosurface angle of the occlusal wall may require 120 degree—130 degree to get supported enamel rods.

Cusp capping: While one or more cusp is to be enveloped by a restorative material the finish line should be at sound enamel margin.

Acid etching: Etching with 37-50% phosphoric acid for a minute increases bonding of certain restorative material to the tooth structure but etching for increased period of time do not significantly affect bonding but results in greater loss of enamel. Beveling of cavosurface margin will give rise to uniform bond strength throughout the area.

Dentin: This constitutes the greatest bulk of the tooth. In the coronal portion it supports the enamel and resist fracture due to its brittleness.

It is much softer than enamel (68 KHN) structurally the dentin is made of shaped dentinal tubules extending from the pulpal areas to the DEJ. Pulpally the inner surface of dentin is lined by odontoblastic cells which extend process into the dentinal tubule.

Loss of enamel or cementum coronal to the dentin will result, in an communication of the pulpal tissue to the oral environment through the dentinal tubules.

Thermal, chemical, osmotic and hydrostatic stimuli can affect the pulp through these tubules and cause pulpal irritation leading to inflammation and potentially to pulp degeneration.

Dentinal sensitivity is the transmission of pain through dentin. some suggest that it is through nerves in the dentinal tubules but other suggest that fluid movements within the tubules brought about mechanical, thermal or osmotic stimuli can cause stimulates the nerves loading to pain.

Dentinal sensitivity is an indication that the tubules are open to the pulp.

Rapid loss of fluid from the dentinal surface as in cavity cutting or air drying can lead to pain.

The fluid movement can be facilitated by tooth brushing probing of cervical exposed dentin in abraded area leading to pain. This can also occur due to thermal changes locally.

Pulp

External stimuli of various kinds can elicit pulpal response cavity instrumentation can cause changes in pulpal tissue depending on the depth of the preparation and extend of the cavity walls.

Microleakage around restorative material results in penetration of oral fluids and bacteria into this space. This can reach the dentinal tubules and cause pulpal response. This microleakage effect on pulp can be minimized by usage of liners, bases and varnishes which act as barriers to bacteria and their toxins. These materials also compensates the setting shrinkage of restorative material or lack of marginal adaptation. They physically shrinkage of restorative material or lack of marginal adaptation. They physically plug the dentinal tubules thus preventing movement of fluid within it.

Cavity varnishes: They form a serious solute layer of few micrometers thick providing adequate barrier. They are to be used below amalgam. Direct filling gold and some bases but not under composites as they impair bonding.

Liners/Intermediary Bases

They provide thermal protection in addition to prevention of microleakage. Some cements like zinc oxide eugenol have sedative/ obtudent effect on the pulp and can be used in deep cavities where thickness of dentin is diminished much. It also kills many organisms beneath it, thus preventing progress of caries and elaboration of toxins leading to pulpal recovery.

Calcium hydroxide can be used on an intermediary bone. It can be used for direct pulp recovery, healing and to produce reparative dentin. in indirect pulp capping $Ca(OH)_2$ acts as a bacteriocidal agent rendering the caries operationally sterile so allowing the pulp to heal.

Cement Bases

They are used to replace lost protein of dentin in deep caries cement like zinc phosphate, reinforced zinc oxide – eugenol, zinc phosphate is an ideal insulating base having thermal conductivity similar to dentin and good compressive strength. Recently GIC is used, it also binds to dentin.

Factors Affecting Dentin and Pulp Health

Any stimulus to the dentin whether it is from carious process, attrition or from operative procedure will affect pulp via the dentinal tubules causes of extends into dentin will evoke pulpal response leading to reparative dentin formation. If this is overcome by the progression of the carious process exposure of pulp will occur. Removal of carious and appropriate restoration before pulpal involvement will aid in pulp returning to normal state.

Instrumentation

Tooth preparation with hand and rotary instruments in removal of caries causes changes in dentin and pulp.

High speed cutting and usage of water coolant and light force results in minimal histological damage to pulp. This response in lesser than that of how speed instrumentation due to application of less force in high speed technique. Water coolant is also important in reducing pulpal response along with force. This helps to dissipitate heat generated during high speed instrumentation.

Cavity Depth

Greater the depth of the preparation, greater will be pulpal response. The pulpal response is affected by the thickness of remaining dentin.

Pulpal more than 2 mm between the cavity and pulp can be substantial barrier against the trauma of instrumentation and relocation.

Pulpal response will be more intense if the preparation in large and deep as compared to small shallow preparation because it depends on the number of tubules cut during the preparation.

Compressed Air

Usage of compressed air for prolonged time to dry the preparation can cause pulpal inflammation but in most cases this change is reversible.

Pins

Using cements for cementing pins for complex restorations can cause pulpal inflammation but this involves in weeks. This response is also seen in threaded pins. The intensity of response is proportional to the proximity of the pinhole to pulp.

Smear Layer

This results when either a carbide or diamond rotary instrument is used. Some say at this smear layer occlude the dentinal tubules preventing bacterial entry but fluid by enter the tubule can cause pulpal inflammation.

Dissolution of smear layer in oral fluids later due to shrinkage of restoration can cause pulpal inflammation later.

Some say that this smear layer harbour bacteria and their products which can cause pulpal inflammation so they should be removed using dilute EDTA solution or usage of potassium oxalate as liner.

Direct Pulp Capping

Some authorities say that it restores tooth vitality and if root canal therapy is to be done later it will not be affected by this procedure while opponents argue that this therapy eventually need RCT and this procedure can lead to dystrophic calcification and obliteration of pulp chambers.

The success or failure of direct pulp capping depends on number of factors such as age of the patient, type of exposure, size of exposure, quality of blood flow and facial restorative materials.

Small pinpoint exposure mechanically in young patient will behaving great potentiality to success.

Indirect pulp capping is the procedure of removal of all carious tissue except the deepest layer near the pulp to prevent exposure and then the area is covered by calcium hydroxide and finally restored after 3 weeks.

The success mainly depends on the vascularity of pulp and vitality of pulp so can be useful in young patients.

Re-establishment of health of teeth by restorative means depends on the mode of treatment initiated, how it is carried out and degrees of result occur. Consideration to this biologically related factors during restoration will maximize tooth health with a healthy oral environment.

Biological Response to Cutting Procedures

This depends on:

1. Depth of cavity preparation and the extend of preparation (R)

2. Heat production during cutting. This depends on:
   - RPM of instrumentation
   - Pressure applied
   - Surface area of contact
   - Usage of coolants
3. Pressure on cutting can cause heal production leading to coagulation of protoplasm and dentine problem.
   It also causes aspiration of odontoblastic nuclei leading to sensitivity.
   - Degeneration of odontoblasts.
   - Influence of microorganism and toxins.
4. Speed of rotation
   More speed à less pressure application required—less effect on pulp.
5. Coolants
   Airwater spray more effective than air along because is
   - Dissipitates heat
   - Increased cutting efficiencies
   - Prolongs life of instrument

   Air alone can cause desiccation and sensitivity.
   Dry cavity preparation without coolants causes.

Increased heat generation leading to pulpal and dentinal changes both reversible and irreversible.
Release of chemical mediators of inflammation.
Accumulation of debris.
Spread of aerosol.
Desiccation or tooth structure.

6. Nature of cutting instruments
   Sharp hand instruments are the preferred ones. In rotary instruments carbide instruments are preferred to stainless steel. A traumatic instruments not preferred due to increased heat products.
7. Size of burs of wheels also affect the pulpal response. Smaller instrument effect little response than larges ones.
8. Vibration employed or vibration of instruments. Instruments which have less vibration is preferred—if vibration are present dentinal sensitivity.
9. Personal variation like age of the patient, condition of pulp, etc. will affect pulpal response to instrumentation.

9 Nomenclature

Two Categories

a. Those having a similar notation for the teeth in each segment.
b. Those having a different notation for the teeth in each segment.

A. Similar notations
Zsigncondy - palace systems
(1861) (1891)

8 ← 1		1 → 8	Permanent
8	1	1 → 8	

E	A	A → E	Deciduous
E	A	A → E	

B. Different notation
Universal

R	12	8	9 → 16	L
	32	25	24 → 17	

R	18	11	21 → 28	L
	48	41	31 → 38	

R	55	51	81 → 65	L
	85	81	71 → 75	

Nomenclature related to various surface of tooth.

Different surfaces are enamel according to adjoining surface.

Labial	_	Forwards lips
Buccal	_	towards cheeks
Lingual	_	Tongue
Palatal	_	Palate
Mesial	_	Towards midline
Distal	_	Away from midline
Incisal	_	Functioning edges of I and C
Occlusal	_	Functioning edges of M and PM
Cervical portion	_	Related to cervical line or neck of tooth
Gingival portion	_	Close to gingiva

Treatment

A	E	F → Y	LD
T	P	O → K	

FDI Systems

Federation Dentine Internationals give two digit systems By Dr. I. Viohl in 1971.

Permanent

Ist digit - indicates quadrant 1 to 4.
Starts from upper right quadrant clockwise.

IInd digit - indicates tooth type 1 to 8. Starts from central incisor to 3rd molar.

Deciduous

Ist - 5 to 8.
IInd - 1 to 5.

10 Instrument and Laser in Operative Dentistry

Instrument refers to a wide variety of implements held in the hand and applied during a treatment procedure.

Dental equipment: Dental chair, the operating unit and X-ray unit.

History

- Previously hand instruments were used for cleaning and placing of enamel and for removal of remaining carious dentine.
- First rotary instruments for cutting tooth tissue were modified hand instruments.
- These drill or bur heads could be twisted in the fingers to produce a cutting or abrasive also.

Dates

1846: Finger ring was introduced with a drill socket.

1858-1862: By Charles Merry – Ist drill with a flexible cable drive and first angle handpiece.

1871: Dental foot engine based on principal of singer sewing machine by Morrison.

1883: Elective dental engine utilizing a cable arm.

1910: Endless cord or a jointed arm. Speed – 4500 to 6500 rpm.

Classification: According to Charbeneav.
It is based upon the use of instrument

1. Cutting instruments
   Hand–Hatchets, Chisels, Hoes, Excavators and others.
   Rotary–Burs, Stones, Disks and Others
2. Condensing instruments
   Pluggers (hand and mechanical)
3. Plastic instruments–Spatulas, Carvers, Burnishes and Packing instruments
4. Finishing and polishing instruments
   Hand–Orangewood sticks, Polishing points, Finishing strips
   Rotary–Finishing burs, Mounted brushes, Mounted stones, Rubber cups, Impregnated disks and wheels
5. Isolation instruments
   – Rubber dam from clamps, forceps, punch
   – Saliva ejector
   – Cotton roll holder
   – Evacuating lips and equipment
6. Miscellaneous instruments - Mouth mirrors, Explosure, Probes, Scissors, Pliers and Others

Hand Cutting Instruments (Fig. 10.1)

Nomenclature for hand cutting instruments by Dr. Black

1. Order – purpose of instrument

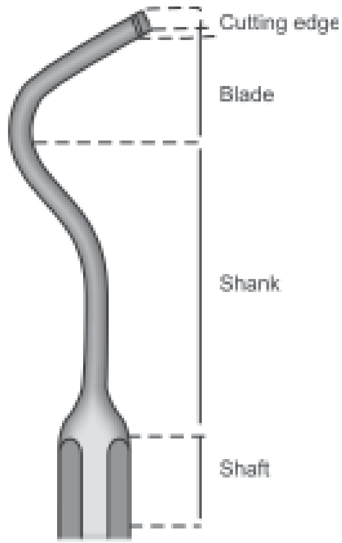


Fig. 10.1: Hand cutting instruments

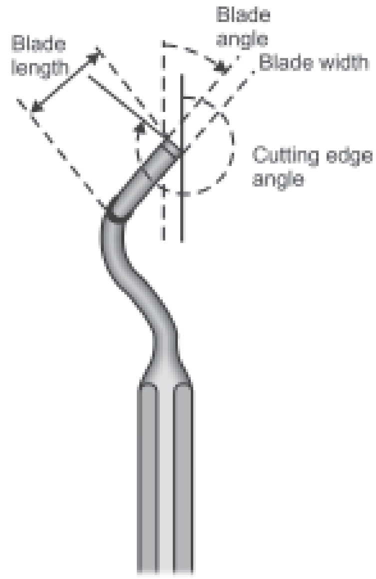


Fig. 10.2: Black's Instrument formula

2. Suborder – position/manner of use
3. Class – form of working end
4. Subclass – shape of the shank

Design Characteristics

Hand cutting instrument consists of three essential parts:

a. Handle or shaft: Small, Medium and Large
b. Shank – connecting the shaft and the blade/nib. Types – Straight, Single, Double and Triples
c. Blade/nib/point/head. This is the functional end of the instrument begins at the L that terminates the shark and is the part of the instrument that bears the cutting edge, condenser face or the nib.

Black's Instrument Formula (Fig. 10.2)

- G.V. Black described an instrument formula that describes the dimension and angulations of the hand instruments.
- Describes the dimensions of the blade, or head of an instrument as well as the angle or angles that exist in the shank that connects the working end to the handle or shaft.

Basic Formula Consists of Four Units

Ist unit: describes the width of the blade in tenths of a mm.
IInd unit: describes the length of the blade in mm.
IIIrd unit: describes the angle the blade forms with the axis of the handle. This angle is expressed in hundredths of a circle or centigrades.
e.g. Hatchet
IVth unit : When the cutting edge or face of an instrument is at an angle other than a right angle to the length of the blade a fourth unit is added to the basic formula.
e.g. GMT – 12-92-10-8 L cutting edge makes with the axis of shaft.

- Angle former

Types

Chisel (Figs 10.3 A to D)

- is an excavation (Instrument used to remove caries) used from planning or clearing enamel and dentin.
- characterized by a blade that terminates in a cutting edge found by a one sided bevel.

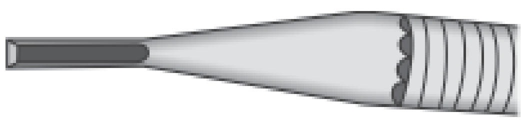


Fig. 10.3A: Chisel

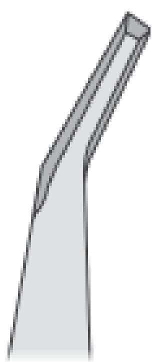


Fig. 10.3B: Mono angle chisel

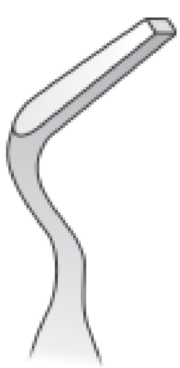


Fig. 10.3C: Bi-angle chisel

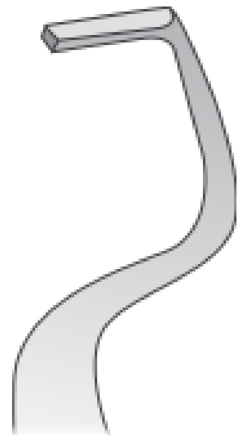


Fig. 10.3D: Enamel hatchet

- Cutting edge is at right angle to the plane of an instrument.

Hatchet (Fig. 10.4)

Chisel bladed instrument with a cutting edge in the plane of the instrument is termed a hatchet.

Paired–right and left with intended ring on shank or shaft.

Use: for delicate cutting (in the preparation especially in incisors).

Spoon excavator: (Fig. 10.5) Cutting angle is semi-circumferential bevel and shapened to thin edge.

Paired–right and left.

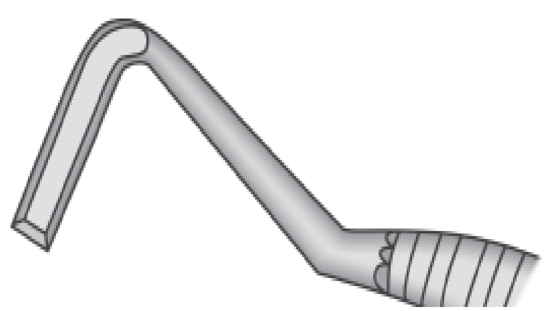


Fig. 10.4: Hatchet

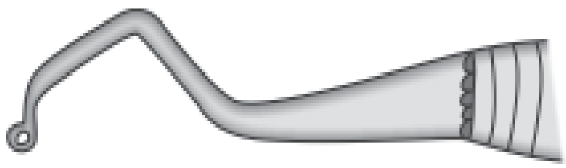


Fig. 10.5: Spoon excavators

Use: for removal of decayed dentin.

Cleoid (claw-like excavation): (Fig. 10.6) like to spoon excavator except blade resembles the claw.

Used: for carving amalgam and excavating decay if areas of difficult access.

Discoid (disc-like) for access.

Discoid (Disc-like) (Fig. 10.7)

– Mesial/distal (double ended instrument)
– Mon / bi-angle

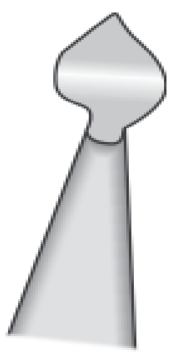


Fig. 10.6: Cleoid excavator

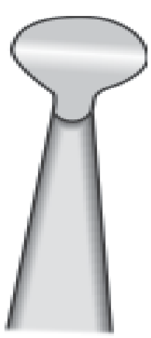


Fig. 10.7: Discoid excavator

– Distal – cutting edge is distal to shaft – "Contrabeveled/reverse-beveled" (Marked with a ring on shaft / shark)
– Used with a push motion.
  Hoe: (Figs 10.8A and B)
– form of chisel when angle of blade is > then 12.5°C.
– pull motion is used.

Use: Use for cutting mesial or distal wall of premolar and molar.

Hatchet: Special form of a chisel.

Use: for splitting/clearing undermined enamel in proximate cavities and on buccal and lingual walls where it is not possible to use a chisel.

Smaller size – anterior teeth.

Large size – posterior teeth.

GMT: Modified hatchet (Fig. 10.8).

Difference

1. Cutting edge is at a perpendicular to the axis of the blade while in GMT is at an angle other than perpendicular to the axial wall.
2. Hatchet shows straight blade while GMT curved.
3. Hatched is single plane instrument while GMT is double planed instrument.

Fig. 10.8: Modified hatchet

Use:
1. For creating a proper bevel at the gingival floor.
2. For trimming of margins of various walls of cavity preparation.

It has four unit formula.

Angle former: Modified chisel, the paired cutting edge is sharpened at an angle (80-85) to the axis of blade, i.e. four unit formula.
There cutting edges – has bevels on side.
Paired instruments – right and left
Single planed instrument.

Use:
1. To accentuate line and point angles in the instrument outline form.
2. Used in cavity preparation for cohesive gold (DFG) to establish retention form.

LASERS

It is an acronym for light amplification by stimulated emission of radiation.
- In 1958, Charles Hand Townes – gives the laser terminology
- In 1960, Theodove Harold Maiman constructed the first laser using a bar of synthetic ruby made from aluminium oxide doped with chromium oxide
- In 1961, Javan et al gave the Helium and Newon laser
- In 1961, Johnson and Gensic-Neodymium droped yettrium aluminium garnet glass rod

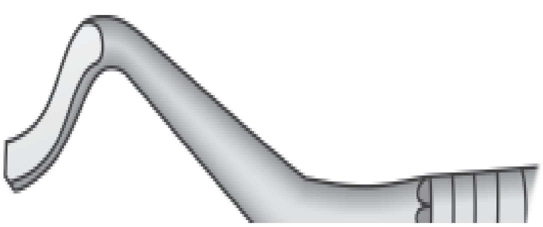


Fig. 10.9: Gingival margin trimmer

- In 1962, Argon laser invention occur
- In 1964, Patel & others – CO_2 laser,
- In 1964, Stern & Goldman – Effects of laser beam impacts on dental hard tissue
- In 1982, Excimer laser
- In 1991, Erbium – YAG laser
- In 1992, Holmium : YAG laser

Laser light is coherent, monochromatic, collimated and unidirectional. It has concentration of energy.

Classification of Lasers

1. Based on wavelength and medium:
   i. CO_2 – 10.60 mm
   ii. Nd: YAG – 1.06 mm
   iii. Argon – 514 and 488 mm
   iv. Excimer – 808 mm
2. Clinical classification
   Soft: Athermic low energy lasers emitted at wavelength which are supposed to stimulate cellular activity, e.g. He-Ne, Galium-Arsenide
   Hard: Thermic lasers emitted at wave length in the visible, infrared and ultraviolet range, e.g. CO_2 argon, Nd: YAG, Excimer, Erbium YAG.

Effect of Laser on Dental Hard Tissues and Pulp

CO_2 laser – enamel
- Temp. 700ºC - enamel may melt
- Temp. < 700ºC – dehydrates without melting

Dentin– with the fluence between 250 and 350 J/cm^2 the surface temp. of dentin reaction the melting point of hydrozyapatite.

Miservendino et al – Laser exposure below 10 J produces temp. rise below 5.5ºC which is within the range of pulpal tolerance, stimulation of dentinogenesis between 800-8000 J/cm^2.

Lynn Powell–with CO_2 laser power densities between 13-102 J/cm^2 irradiation of enamel without damage to pulp.

Nd: YAG Sound enamel – continuous fluence between 180 and 2228 J/cm^2 produce slight surface overheating.

Uses of Lasers in Operative Dentistry:

1. Caries detection (Laser fluorescence method)
2. Losing of carious enamel - by Nd: YAG laser at 3 watt. Capable of etching enamel or cutting carious enamel and both sound and carious dentin.
3. Repairing of incomplete vertical fracture.
4. Improved marginal adaptations and restorative using lasers thus giving smoother surface for casting fit and filling materials.
5. Argon loser is used in photocuring of composite resin – homogeneous penetration occurs reducing polymerization shrinkage.
6. Pit and fissure sealed composed of hydroxyapatite effective attached by CO_2 lesser.

Advantages and Disadvantages of Lasers:

Advantages	*Disadvantages*
1. Without anesthesia	1. Expensive
2. No vibration and metallic sound	2. Professionally trained persons
3. Bacteriocidal effect	3. Flaking of enamel and dentin
4. Long lasting DT sealing	4. Thermal stresses on pulp
5. Better control-light cure	5. Hazards to operator
6. No aerosol formation	6. Necrotic zones
7. Less traumatic, bloodless field	7. No tactile sensation
8. Very fine incision line	8. Mutation and carsinogenic

11 Biocompatibility of Dental Materials

INTRODUCTION

Biocompatibility is defined as the compatibility of manufactured materials and devices with body tissues and fluids. The field of dental materials shares the problems of biocompatibility with other fields of biotechnology. Today, in the development of an intraoral material, one must consider not only the strength, esthetics, or functional aspects of the material, but its bio-compatibility as well. Thus, biocompatibility is important to manufacturers and material scientists. The field of biocompatibility is broad, and encompasses the development of new testing methodologies, the survey of materials *in vitro* for potential bio-compatibility in different biological contexts and the evaluation of materials in a clinical setting.

Because of the increasing concern of the American Dental Association is early 1930's regarding the safety and biocompatibility of dental materials and devices, Dixon and Rickert in 1933 attempted to develop a uniform test for all dental materials. Other early attempts to standardize technique was carried out by Mitchell (1959) on connective tissue and by Massler (1958) on tooth pulp.

The document from this text, "Recommended Standard Practices for Biological Evaluation of Dental Materials" was published in 1972. This original document was quite primitive; it was revised and published in 1979 as document no 41. A similar document was produced and published by the Federation Dentaire International (FDI) in 1984. Currently a new document is being developed that will meet international needs, particular those of the nations of the European Union. The draft documents entitled "Preclinical evaluation of biocompatibility of medical devices need in Dentistry – Test methods".

According to Dorland's medical dictionary, the term biocompatibility may be defined as "being harmonious with life and not having toxic or injurious effects on the biologic function.

REQUIREMENTS FOR BIOCOMPATIBILITY OF DENTAL MATERIAL

It should not be harmful to the pulp and soft tissues.

It should not contain toxic diffusible substances that can be released and absorbed into the circulatory system to cause a systemic toxic response.

It should be free of potentially sensitizing agents that are likely to cause an allergic response.

It should have no carcinogenic potential. In a broad sense, a biomaterial can be defined as "any substance, other than a drug, that can be used for any period as a part of a system that treats, augments or replaces any tissue, organ or function of the body".

Dental materials are used in human for short or long periods and like other specialized materials used in orthopedics, cardiovascular prosthesis, plastic surgery and ophthalmology, they function in close contact with various human tissues.

Collectively they should meet the requirements of biomaterials, biocompatibility and bioacceptance.

When dentists purchase a material they should know if it is safe, and if it is safe, how safe it is relative to other materials.

CLASSIFICATION OF MATERIALS

Materials may be classified into the following types from the perspective of biological compatibility:

- Those which contact the soft tissue within the mouth
- Those which could effect the health or vitality of the dental pulp
- Those which are used as root canal filling materials
- Those which effect the hard tissues of the teeth
- Those used in the dental lab which though not used in the mouth are handled and may be accidentally ingested or inhaled.

TESTS FOR EVALUATION OF BIOCOMPATIBILITY

The purpose of biocompatibility test is to eliminate any potential product or component of a product that can cause harm or damage to oral or maxillofacial tissues. Biocompatibility tests are classified on 3 levels.

Group I: Primary Tests

The primary tests consist of cytotoxic evaluations in which dental materials in a fresh or a cured state are placed directly on tissue culture cells or an membranes (barriers such as dentin disks) overlying tissues culture cells that react to the effects of products or components that reach through barriers.

If a material is found to be highly cytotoxic, there are several ways to improve it:

1. Reduce the level of toxic substance leached.
2. Consider a use for the material in which the leaching product will not affect the individual.
3. Use a different formula for the material.

Types of Cytotoxicity Tests

1. *Cell number and growth test* assess the cytoxicity of a material by measuring cell number of growth after exposure to a material.
2. *Membrane permeability test* denotes the ease with which a dye can pass through a cell membrane. Vital or non-vital dyes may be used for this.
3. *This test uses biosynthetic or enzymatic activity* of cells to assess cytotoxic response. The measurement of DNA synthesis or protein synthesis is a common example of this type of test.
4. *Genotoxicity test*: Mammalian or non-mammalian cells, bacteria, yeasts or fungi are used to determine whether gene mutations, changes in chromosomal structures, or other DNA or genetic changes are caused by the test materials, devices and extracts from materials. Two such assays for mutagenesis are "Ame's test' and "Styles' cell transformation lost.

Group II: Secondary Test

At this level the product is evaluated for its potential to create systemic toxicity, inhalation toxicity, skin irritation and sensitization, and implantation response.

In the systemic toxicity test such as the oral median lethal dose (LD50) test, the test sample is administered daily to rats for 14 days either by oral gavage or by dietary inclusion. If 50% of the animals survive the product has passed the test.

The dermal toxicity test is important because of the great number of chemical substance, not only dental products that we contact daily. A primary irritant is capable of producing an inflammatory response in most susceptible people, after the first exposure. Once a toxic material, product, or component is identified, it can be replaced, diluted, neutralized or chelated to reduce the risk for toxicity.

In addition, irritation and sensitization must be differentiated. *Irritation* is defined as an inflammation brought about without the intervention of an antibody or immune system, whereas sensitization is an inflammatory response requiring the participation of an antibody system specific for the material allergen in question.

The simulate *dermal toxicity*, the test material is held in contact with the shaved skin of albino rats for periods ranging from 24 (one exposure) to 90 days (repeated exposures). The animal must be received an occlusive covering to prevent mechanical loss of the contacting agent, even by evaporation.

The *inhalation toxicity* test is performed on rats, rabbits or guinea pigs in an exposure chamber with aerosed preparations by releasing the spray material around the head and upper trunk of the animals. The animals are subjected to 30 seconds of continuous spray released at 30 minutes intervals. After 10 consecutive exposure, the animal is observed over a 4 day period, if any animal dies within 2-3 minutes, the agent is considered very toxic. If none of the animals die, the agent is not likely to be hazardous to humans (Stanley 1985).

Implantation Test

For this *in vivo* test, animal species is selected according to the size of the implant test specimen and the intended duration of the test in relation to life span of the animal.

For short term, (less than or equal to 12 weeks study) subcutaneous tissues or muscle of animals such as mice, rats, hamsters or guinea pigs is chosen. For long-term tests (more than 12 weeks) muscles or bone of animals such as rabbits, dogs, sheep, goats are subhuman primates with relatively long life expectancy are used.

For subcutaneous or muscle implantation, the test implant is packed into various types of plastic tubes. For bone implantation, cylinder of two materials are inserted into drilled holes made by cutting with irrigation into the lateral cortex of a fermure or tibia. Histopathologically, one evaluates the formation of new bone onto the surface of the test material without intervening connective tissue.

Success of a dental implant it estimated by (1). Penetration of periodontal probe along the side of the implant (2), Mobility of the implant (3) Radiographs indicating osseous integration or radiolucencies around implant.

Group III: Preclinical Usage Tests

With regard to drugs, the FDA is most concerned that efficacy and usage test are thoroughly conducted and scrutinized.

However, in regard to dental materials the manufacturer has as long as 7 years to prove efficacy after the product has reached the open market with FDA approval.

A dental practitioner should not assume that a dental product that can be purchased or promoted, in permanent dental publications necessarily fulfills all the advertised claims. It is better at this time to determine if the product has the ADA seal of acceptance that is granted when sufficient data are available to provide evidence of safety and efficacy through biologic, laboratory and clinical evaluations.

Pulp and Dentin Usage Test

This test is designed to assess the bio-compatibility of dental materials placed in dentin adjacent to the dental pulp. Non rodent mammals with recently erupted. Class V cavities are cut on the buccal and labial surfaces or both using sharp burs and air water spray to leave 1 mm or less of tubular dentin between the floor of the cavity preparation and the pulp. Appropriate number of cavities are restored. Some are used as negative control using some form of zinc oxide eugenol. For a positive control, a restorative material is selected that consistently induces a moderate to severe pulp response [$Ca(OH)_2$].

The animals are sacrificed after 7 days, 28 $\pm$ 3 days, and 70 $\pm$ 5 days. After routine histopathologic processing the specimens are graded for the degree of inflammatory response, the prevalence of reparative dentin formation in the pulp, and the number of micro organisms (microleakage) entrapped in the surrounding cavity walls and cut dentinal tubules.

As a rule, the less reparative dentin that is subsequently formed the better, because more bulk of vital pulp tissues is available to deal with future episodes of caries and dental treatment.

Pulp Capping and Pulpotomy Usage Test

The testing procedures here are similar to the above except that the pulp is merely exposed for the pulp capping evaluation and is partially removed for the pulpotomy assessment. A calcium hydroxide product is used as the negative control. The animals are sacrificed after 7 $\pm$ 2 days and 70 $\pm$ 5 days.

Observations are made for dentinal bridge formation, adjacent to or subjacent to the applied capping material. The quality or structures of the covering dentinal bridge is determined. It is preferred to find a bridge directly against the capping material, implying minimal destruction of pulp tissue at the time the pulp capping agent was applied.

Endodontic Usage Test

Here the pulp is completely or almost completely extirpated from the pulp chamber, root canals and reduced by obturating test materials which is either ZOE alone or Grossman's sealer. The animals are sacrificed after 28 $\pm$ 3 days and 13 $\pm$ 1 week. The teeth are removed along with their surrounding apical periodontal (soft and hard) tissues in a single block. The degree of inflammation is evaluated. For the biocompatible material, one should observe minimal or no response and the shortest resolution time if a response is detected. The time is affected by the resistance of the test material to degradation and dissolution. When the latter occurs, tissue fluid accumulates in the porous areas of obturation material, and it may contribute to the growth of microorganisms, recurrent infection and clinical failure.

ALLERGIC RESPONSES TO DENTAL MATERIALS

1. Allergic Contact Dermatitis

Allergic contact dermatitis now ranks as the most common occupational disease.

The interval between exposure to the causative agent and the occurrence of clinical manifestations usually varies between 12 and 48 hours, although it may be as short as 4 hours or as long as 72 hours.

Dermatitis usually occurs where the body surface makes direct contact with the allergen. In some cases, however, the relationship is not quite as straight forward.

A skin condition that is frequently confused with allergic contact dermatitis is primary irritant dermatitis, which is caused by a simple chemical insult to the skin, such as that observed in "dishpan hands". A prior sensitization dermatitis is dose dependent, whereas allergic contact dermatitis is virtually dose independent.

Personnel and patients involved in orthodontics and pediatric dentistry have the highest incidence of side effects, amounting to 50% of the personnel and 1% of the patient. An allergic contact dermatitis associated with monomers of bonding agents frequently involves the distal parts of the fingers and palmar aspects of fingertips.

Allergy to Latex Products

On March 29; 1991, the FDA issued a bulletin (US FDA, 1991) in response to the increasing number of latex related allergic reactions. Although rubber has been identified as a cause of contact sensitivity since the mid 1940's, Malten and associates reported an increasing incidence of hypersensitivity in 1976.

Hypersensitivity to latex – containing products may represent a true latex allergy or reaction to accelerators and antioxidants used in latex processing, or Thiuram (chemical used in fabrication of latex articles or to the polyether component in latex rubber gloves worn by dentists).

A survey of periodontist, hygienist and dental assistants revealed that 42% of these professionals reported adverse reactions to occupational materials, most of which were related to dermatoses of the hands and fingers. Adverse reactions in 3.7% of 323 were associated with latex gloves.

Reactions vary from simple types such as localized rashes and swelling to more serious types such as wheezing, and anaphylaxis. Dermatitis of the hands is the most common adverse reaction. A history of eczema and a familial history of allergies are predisposing factors. Repeated exposure and duration of exposure play a role in the degree of responses.

Most serious allergy occurs when products such as gloves and rubber dam contact the mucous membranes. The adverse reaction may include respiratory distress.

Allergic Contact Stomatitis

Allergic contact stomatitis is by for the most common adverse reaction to dental materials. The adverse reactions may be observed as local or contact type lesions but reactions distant from site (such as itching on the palms of the hand or soles of the feet) are also reported.

The long-term reactions are dependant on the composition of the materials, to toxic components, the degradation products, the concentrations of absorbed and accumulated components, and other factors associated with substances leached from these materials.

The most definitive diagnostic test for allergic contact dermatitis or stomatitis is the *Patch test*. The suspected allergen is applied to the skin with the intent to produce a small area of allergic contact dermatitis. The test generally takes from 48 to 96 hours, although a reaction may appear after 24 hours. This reaction may cause hyperemia, edema, vesicle formation and itching.

Dental materials contain many components known to be common allergens such as chromium, cobalt, mercury, eugenol components of resin based materials, colophonium and formaldehyde. Minute amount of formaldehyde may be released as a degradation product of unreacted monomers in dentures made from resin based composite materials. To avoid this, authors recommended that autopolymerized appliances and dentures should be immersed in water for 24 hours before being worn. Such allergic reactions affect not only patients but also dental personnel working with such materials.

Although few gingival reactions have been reported following contact with composite materials, the permeability of the gingival epithelium enhances the penetration of leachable components and thus the potential for toxic and allergic reactions.

Under extremely rare conditions (1:1 million), patients who have been sensitized to gold may react to gold restoration with burning sensation and lichenoid lesions of the oral mucosa in contact with gold alloy as well as generalized systemic reactions.

Lichenoid reactions representing a long-term effect in the oral mucous membrane adjacent to amalgam and resin base composite materials occur quite often.

Chemicals that may produce allergic contact stomatitis on a short-term basis can also be found in mouth washes, dentifrices, and topical medications such as cough drops. They can cause burning, swelling and ulcerations of the oral tissue.

Allergy to Nickel

Only about 30% of those patients with a human nickel allergy develop a reaction to an intraoral nickel chromium dental alloy. These appears to be little danger of producing an allergic reaction to nickel by placing a nickel containing alloy intraorally except erythema and burning sensation. A higher incidence of nasal and sinus cancer has been found among nickel refinery workers but this higher incidence has been linked to a nickel carbonyl that is used in the refining process. Dermatitis has also been reported.

Recommendations by NIOSH for Use of Nickel

- The limit for safety is 15 mg.
- Adequate protection for workers is essential.
- Proper exhaust system should be available
- Patch testing for patients reported to have nickel allergy should be done.
- Lead components have reported to form Burtonian line in the gingival of many patients.

Allergy to Nickel

Allergy reported:
Males : 7.9%
Females : 9.4%

Toxicity and Allergenicity of Beryllium

Berylliosis is an inflammatory lung disease resulting from the inhalation of beryllium dust or fumes. Beryllium containing alloy should be ground only with ventilation (Mackert et al 1988). Dermatitis ulcers and corneal burns may be caused.

Beryllium though used due to:
- Its improved casting
- Decreased fusion temperature
- Increased strength

The following precautions should be taken:
- Adequate local exhaust during casting, grinding and polishing
- Good respirators if no exhaust is available
- Warning signs should be put in front of the working area
- Good and clear coats to be given to workers every week
- Dusting of clothes should be done with vacuum machine
- Proper education of workers
- Standards to be followed
- Not to exceed 2 mg m/m^3/person in a 8-hour working day

The Mercury Controversy

Like all other materials in the world, mercury (Hg) has the potential to be hazardous if not managed properly.

The contribution of mercury derived from dental amalgam to the overall body burden has been the source of much controversy but appears to be relatively low.

However, mercury hypersensitivity which to claimed is be a potential hazard is due to the immune system response to very low levels of mercury.

Much of the confusion associated with the biocompatibility of amalgam stems from ignorance of the signs and symptoms of mercury poisoning. Headache, one of the symptoms most frequently claimed to disappear on removal of amalgam is not a symptom of mercury poisoning. The recognized symptoms of chronic mercury poisoning include weakness, fatigue, anorexia, weight loss, insomnia, irritability, shyness, dizziness and tremors in the extremities. Also more prominent symptoms are kidney inflammation, swollen gums and pronounced nervous system disturbances including Alzheimer's diseases.

The average mercury level in blood of subjects with amalgam is 0.7 ng/ml whereas subjects without amalgam show a blood mercury level of 0.3 ng/ml.

Dental Mercury Hygiene Recommendations according to ADA

1. Symptoms: Know the potential hazards and symptoms of mercury exposure such as the development of sensitivity and neuropathy.
2. Hazards: Know the potential sources of mercury vapour such as (a) spills (b) Leaky dispensers or capsules (c) polishing amalgam (d) removing amalgams and (e) heating of amalgam contaminated instruments.
3. Ventilation: Provide proper ventilation in the workplace by having fresh air exchange and periodic replacement of filters which may act as traps of mercury.
4. Monitor office: Monitor mercury vapor level in the office periodically (by dosimeter badges). The current OSHA limit for mercury vapor is 50 microgram cubic meter in on 8 hours work shift over a 40 hours work week.
5. Monitor personnel: Monitor office personnel by periodic urine analysis (the average mercury level in urine is 6:1 mg/liter for dental office personal).
6. Office design: Use proper work area design to facilitate spill containment and clear up.
7. Precapsulated alloys: Use precapsulated alloys to eliminate the possibility of bulk mercury spill. Otherwise store bulk

mercury properly in unbreakable containers on stable surface.
8. Amalgamator cover: Use an amalgamator fitted with a cover.
9. Handling care: Use care in handling amalgam. Avoid skin contact with mercury or freshly mixed amalgam.
10. Evacuation system: Use high volume evacuation when finishing or removing amalgam. Evacuation system should have traps or filters. Check, clean, or replace traps and filter periodically.
11. Masks: Change mask as necessary when removing amalgam restorations (the mask will trap airborne particles and may discourage vapour transport but will not stop vapor passage)
12. Recycling: Store amalgam scraps under radiographic fixer solution in a covered container. Recycle amalgam scraps through refiners which are properly licensed by the ADA.
13. Contaminated items: Dispose off mercury contaminated items in sealed bags according to applicable regulations.
14. Spills: Clean up spilled mercury properly by using trap bottles; tapes or fresh mixes of amalgam to pick up droplets or use commercial cleanup kits. Do not use household vacuum cleaners.
15. Clothing: Wear professional clothing only in the dental operatory.

HARMFUL INTERACTION OF MATERIALS WITH TISSUES

Normal metabolism and physiology of cells and tissues altered stages of injury:

1. Biochemical lesion
2. Functional lesion
3. Morphological lesion, i.e.

Injury
↓
Tissue infarction and ischemia
↓
Reduction oxidative phospharylation and
↓
ATP production
↓
Failure of sodium pump and water retention
↓
Reduced protein synthesis
↓
Loss in cell integrity with release of lysosomal enzymes
↓
Cell degeneration, death and necrosis

MINIMIZING DENTAL IATROGENESIS

The word *iatrogenesis* is defined as the creation of side effects, problems, or complications resulting from treatment by a physician or dentist.

Although dental products and techniques are approved and certified, the practitioner should follow explicity the instructions and directions of the manufacturers; any variance in technique and substitution of component of another manufacturer, no matter how subtle the change, may prove detrimental to the long-term success of the treatment. If products have narrow limits for safety, special precautions should be adopted to reduce unnecessary risks or to prevent adverse effects.

PARAMETERS OF ASSESSMENT

It is desirable to have a remaining dentin thickness (RDT) of 1 mm or less in all categories. Categories and time intervals are compared to determine from the grading of the histopathologic characteristics whether a pulp lesion is resolving, persisting or interfying. A favorable situation requires that the intensity of a pulp response, if any, should be higher initially and decrease with increasing postoperative time intervals (PTIS).

Any system, technique, procedure, or restorative material that creater an abscess or a lesion extending of beyond the tubules in unacceptable.

PULPAL RESPONSE TO VARIOUS TECHNIQUES AND SPECIFIC AGENTS

In most instances, 2 mm of dentin thickness provides an adequate insulating barrier against the more traumatic thermal operation techniques and the irritating components of most restorative materials. At lesser dentin thickness however, inflammatory responses develop and increases in severity as the dentin thickness decreases.

At low handpiece speed (6000 to 20000 rpm) with an air–water spray, a cavity preparation 2 mm from the pulp elicits a minimal pulp lesion deposits restoration will ZOE. As the cavity preparation approaches within 1 mm of the pulp, the intensity of the response increases. The inflammatory responses is significant in the first 24 hours. Many neutrophils migrate into the superficial and deeper tissues of the pulp, odontoblasts are displaced into the dentinal tubules, and focal hemorrhages occur throughout the affected region.

Despite the apparent severity of the initial lesion, the inflammatory response begins to resolve in a few days as acute inflammatory cells are replaced by mononucleated cells. Because the effect of the cavity preparation is once only traumatic episode, little inflammation will be present by 15 days and by 30 days reparative dentin will begin to form and reach its maximum thickness after 60 days. Cutting at high speed ($\geq$50000 rpm) with air-water spray and ZOE restoration produces less trauma.

I. Reaction of Pulp Dentin Organ to Amalgam

Conventional amalgam restoration have generally been considered to be either inert or mildly irritating to the pulp.

However, various irritating ingredients are responsible for deleterious effects on the pulp dentin organ.

1. Mercury

Residual mercury in large build up requiring the use of high mercury, mixes of amalgam, can diffuse from the restoration surrounding dentin. Eventually, it can penetrate the pulp tissue via the dentinal tubules. Such mercury has been reported to poison odontoblasts, subsequently reducing predentin and secondary dentin formation. At the very least, discoloring of involved dentin occurs.

2. Galvanism

These small electrical currents are especially present when dissimilar metal restorations are in contact or in occlusion with amalgam. Galvanism is, in fact, inherent in an amalgam restoration, due to multiphased nature and the facts that certain areas will be more stressed than others during condensation and certain areas on the surface will contain scratches and irregularities even after scrupulous finishing and polishing.

3. Thermal Conductivity

As with any metal, amalgam has the ability to transmit thermal energy, which can be very detrimental to the dentin and pulp. This effect is especially harmful when the restoration is close to the pulp chamber or root canal system peripheries.

4. Energy of Condensation

The detrimental limits of condensation energy differs not only form individual to individual, but also from tooth to tooth. If the "effective depth" of the cavity preparation is very limited, excessive condensation can cause a disruption in the paving continuity of the odontoblasts, or aspiration of the odontoblast or their ruclei into the dentinal tubules. In rare instances, cracking of the dentin bridge can occur.

5. Heat of Finishing and Polishing

During the finishing and polishing of amalgam restoration, the generated frictional heat may be readily transmitted through the restoration to the underlying pulp dentin organ. Local burns lesions, varying in their extent, are created. Because of the enhanced possibility of bacterial deposition in this burned area through anachoresis, the destructive effect may be magnified and this may cause reversible pulpitis.

6. Delayed Expansion

Moisture contaminated amalgam can create an expansion of such magnitude that it may not always be directed toward the outer surface of the restoration. Axially or pulpally directed expansion will exert tremendous pressure in the pulp dentin organ.

7. Corrosion Products

These chemical by products of the corrosive process include tinoxide, copper oxide and silver sulfides. Unfortunately they are unavoidable in any amalgam restoration, and any factors which enhances corrosion will consequently increase the by products. All are free to migrate toward the pulp tissue if the pulp dentin organ is left unprotected or if diffusion activity is increased by galvanic and thermal energy.

8. Induced Stress

Micromovement, of amalgam restorations can result from among other things, an ill-designed cavity preparation. If the stresses induced by such movement exceed certain limits or concentrations at thinned areas of the dentin bridges, they may be transmitted to the underlying pulp tissues in a way that would interfere with the natural functions of the periodontal organ.

IX. Plaque Adhesion

Occurring due to its surface roughness, amalgam is an adherence for bacterial plaque. When this occurs at the tooth amalgam interface, it can create sufficient toxins to diffuse toward the pulp. In some instances, the resulting irritation is irreversible.

X. Loose Restoration

As a result of deficient retention or interfacial failure, loose restoration may reveal environmental irritant to the PD organ with the expected sequelae.

Generally with an effective depth of 2.5 mm or more, the pulp dentin organ will respond with a healthy reparative dentin. In this case, application of varnishes should be routinely done on the walls and floors of the cavity to promote biocompatibility.

In cavities with effective depth of 1-2 mm a base of modified ZOE is to be placed in specified locations followed by generous varnish over all walls and floors.

In cavities with an effective depth of less than 1 mm, $Ca(OH)_2$ should be used as a sub-base with modified ZOE as base and varnish is applied on the walls and floor of the cavity.

II. Biocompatibility Composites

Concerns about biocompatibility of restorative materials usually relate to the effect on the pulp from 2 aspects, the inherent chemical toxicity of the material and marginal leakage.

Chemical insult to the pulp from composites is possible if components leach out or diffuse from the material and subsequently reach the pulp. Properly polymerized composites are relatively biocompatible, because they exhibit minimal solubility and unreacted species are leached in small quantities. From a toxicolgic point of view, these amounts are too small to cause toxic reactions.

However, from an *immunologic point* of view, under extremely rare conditions, some patients and dental personnel can develop an allergic response to these materials.

Uncured composite materials at the floor of a cavity can serve as a reservoir of diffusible components that can induce long-term pulp inflammation. This situation is of particular concern for the light activated materials. If a clinician attempts to polymerize too thick a layer of resin or if the exposure time to the light is inadequate, the uncured or poorly used material can release leachable constituents adjacent to the pulp.

The second biologic concern in associated with shrinkage of the composites during polymerization and the subsequent marginal leakage. The marginal leakage might cause bacterial ingrowth, and these microorganism may cause secondary caries, pulp reactions or both. The restorative procedures must therefore be designed to minimize the polymerization shrinkage and marginal leakage.

The chemically used filled resin if not properly lined still caused chronic pulpitis which persists for an indefinite time in cavities of ordinary depth (1 mm). The use of matrix pressure to enhance adaptation to the cavity walls during polymerization also adds to the irritating potential of composites.

For visible light cured resin composites failure to completely polymerize the resin leads to high concentration of residual unpolymerized resin reaching the pulp. The visible light cured composites are better than the U-V light cured composites as they provide a greater depth of cure, shorter curing time, less porosity and more wear resistant composite restoration.

Resin-based Composites Cements (Dual Cure)

The dual cure resin composites are inserted into the cavity and hold under pressure by means of preformed, clear, plastic, cervical matrices until polymerization is completed. Only when the duel-cure resin cement received no visible light energy does the average pulp response levels exceed the accepted level of biocompatibility and resemble pulp response associated with the chemically cured resin composites developed earlier. When dealing with dual cure types of resin composites, it is important to use an adequate light curing time. If time is inadequate, the self cure mechanism may not be effective to complete polymerization of the remaining uncured resin that was light cured. Excessive pulp responses may then occur.

Precautions to be taken when using composites:

1. Allow complete polymerization of the material
2. Adequate time of exposure to the light
3. Avoid bulk increments
4. Avoid incorporation of voids
5. Location and intensity of the light sources should be as close as possible
6. Avoid looking directly into light source
7. Use protective eye glasses
8. Polymerization shrinkage is compensated by use of new dentin bonding agents
9. Surface treatment of enamel/dentin is essential.

Pulpal Response to Acid Etching

Although acid etching of cavity walls is cleansing, acid etching is specifically designed to enhance the adhesion of restorative materials. In case of dentin, the ability of etching to improve long-term adhesion has been questioned. Acid cleaners applied to dentin have been shown to widen the openings of the dentinal tubules, increase dentin permeability and enhance bacterial penetration of the dentin. One study showed that in deep cavities, pretreatment of the dentin with 50% citric or 50% phosphoric acid for 60 seconds is capable of significantly increasing the response of the pulp to restoration materials. Results of one physiologic investigation have shown that acid etching of small class V cavity having remaining dentin thickness of 1.5 mm has little effect on pulpal blood flow. Thus, direct effect of the acid on the pulpal microvascular vessels appears to be negligible, possibly because of rapid buffering of the acid by the dentinal fluid. However, in very deep cavities acid etching may contribute to pulpal injury.

III. Conditioning Agents

Conditioning procedures are used with both resin composite systems and GICs. Before a resin composite or a GIC restorative material is placed, surface contaminants must be removed to permit the micromechanical attachment or the ionic exchange of the dental material with the tooth structures. For this, acids like 37% and 50% H_3PO_4 etc. may be used. However, these high acid concentration, when applied for extended intervals remove the smear unit (the smear layer and dentinal tubule plugs) funnel the orifices of the tubules, deplete the surface ions available for chemical bonding, denatures the exposed collagen fibers, and increase the potential for severe pulp responses to restorative material placed subsequently.

Some scientists recommend that the smear layer should remain, but in a modified form, whereas others proposed that the smear layer be completely removed to optimize the bonding of restorative materials to dentin.

The agent that removes the smear layer in 5 seconds can cause considerable demineralization if left in place for 30 seconds, and it can produce pulp damage it left for 60 seconds.

Thus, these studies suggest that only the surface of the dentin (10 mm depth) needs to be modified and not its deeper layers. Conditioning techniques that are associated with weaker acids, shorter periods of application, and the elimination of rubbing and scrubbing produce a minimal pulp response and satisfactory bonding.

IV. Dentin Bonding

When the dentin surface is cut as in a cavity preparation, the surface that remains is covered by a 1-2 µm layer of organic and inorganic debris. This layer has been named the smear layer.

The presence of the smear layer is important to the strength of bonds of restorative materials and to the biocompatibility of those bonded materials.

Numerous studies have shown that removal of the smear layer improves the strength of the bond between dentin and restorative materials with contemporary dentin bonding agent, although earlier research with older bonding agents showed the opposite. A variety of agents have been used to remove the smear layer including acids, chelating agents such as EDTA sodium hypochlorite and proteolytic enzymes. Removal of the smear layer increases the witness of the dentin and demands that the bonding agent be able to wet dentin and displace dentinal fluid. The mechanism by which bonding occurs remain unclear, but currently it appears that the most successful bonding agents are able to penetrate into the layer of collagen that remains after acid etching, crating a “hybrid layer” of resins and collagen in intimets contact with dentin and dentinal tubules. The strength of the collagen itself has also been shown to be important to bond strengths.

From the standpoint of biocompatibility the removal of the smear layer may pose a threat to the pulpal tissues for three reasons.

First, its removal jwtaposes resin materials and dentin without a barrier, and therefore increases the risk and that these materials can diffuse and cause pulpal irritation.

Second, the removal of the smear layer makes any microleakage more significant because a significant barriers to the diffusion of bacteria or bacterial products towards the pulp is removed.

Third, the acids used to remove the smear layer are a potential source of irritation themselves. Nevertheless, removal of the smear layer is now routine because of the superior bond strengths that can be achieved.

Reactions of Pulp to Microleakage

There is evidence that restorative materials may not bond to enamel or dentin with sufficient strength to resist the forces of contraction on polymerization, wear, or thermal cycling. When debonding occurs, bacteria, food debris, or saliva may be drawn into the gap between the restoration and the tooth by capillary action. This effect has been termed microleakage.

Brannstom and colleagues have proposed that infections caused by penetration of microorganisms from marginal leakage around the restoration and especially beneath, it is a greater threat to the pulp than is the toxicity of the restorative material.

No doubt pulp lesion that increases in intensity after a PTI longer than 1 week can be caused by the ingress of microorganisms, but to attribute severe pulpal lesions in short term experiments to microorganisms and their by products without relating such lesions to the potential toxicity of restorative materials themselves is questionable.

The hydrolytic pressure of pulp *in vivo* is higher than that of the mouth, and the dentinal fluid moves peripherally through the tubules. Despite this fact, it is resumed that microleakage permits bacteria and their by products to travel in the opposite direction toward the pulp. This increased amount of moisture can create a biofilm and impair the adhesion potential of subsequently placed restorative material.

Although microorganisms may continue to the pulp responses beneath a restoration, they appear to be unable to sustain a long-standing irritation to the pulp. Unless recurrent caries develops under a clinically defective restoration, the dentin permeability to noxious bacterial agents decreases over time, even under continued bacterial provocation, allowing the pulp to heal. This may partially explain why pulps remain vital in most restored teeth. Consequently when pulp devitalization occurs after a restorative procedure, it probably results from the combined effect of the mechanical injury induced during cutting of the tooth substance, the toxicity of the restorative material, and the action of bacteria.

Generally, most newly placed materials are somewhat toxic and bactericidal but lose their antibacterial effects as they cure and age. In the first few days, amalgam and silicate cements are as antimicrolevel as ZOE, but the antibacaterial effects of ZOE tests much longer.

One feature which is of advantage in case of amalgam (low Cu amalgam) is decreased microleakage with time due to accumulation of corrosion products at the margins.

V. Impression Materials

The ADA specification for testing biocompatibility includes dental impression materials, despite the fact that the probability of allergic or toxic reactions from impression materials or their components is small. Comparisons of cell cytotoxocity for different impression materials show that polysulphide resulted in the lowest cell death count.

Perhaps the most likely elastomer induced biocompatibility problem occurs when a piece of the impression material is left in the gingival sulcus. The irritation can range from minor to severe. The radiopacity of the lead containing polysulphide materials is an advantage in these situations, as is the materials resistance to tearing.

Silicone is one of the most biologically inert materials. Thus, it is highly unlikely that condensation or addition silicone impression materials would cause a biocompatibility problem. The one danger is the possibility of leaving torn impression material in the gingival sulcus. Because the silicone materials are not radiopaque, it can be difficult to detect the presence of torn material. Careful visual inspection of the impression to check for torn areas is needed to ensure that the necessary detail is recorded. If evidence of tearing is detected during this inspection, the clinician should immediately check the tissue to remove remnants of the impression.

Originally there was some concern about hypersensitivity to the polyether catalyst system. Contact dermatitis from the polyether, especially to the dental assistant has been reported. However, recent studies indicate no cytotoxic effect associated with the imine catalyst. The polyether impression material did produce the highest cell cytotoxicity scores and the lowest viable cell count after multiple exposures.

In alginates, fluffing of particles releases silica particles which are carcinogenic. Now-a-days dust less alginates are available which incorporate glycerine to agglomerate the particles making them heavy and less dangerous to the clinician.

ZOE impression paste have the disadvantage of causing burning and stinging sensation and also it may cause gastritis.

VI. Retraction Cords

Adrenaline impregnated cords are contraindicated for hypersensitive and cardiac patients. Careful handling of gingival tissues is essential.

VII. Biocompatibility of Dental Cements

1. Silicate Cement

With respect to biologic properties, the pH of silicate cement is less than 3 at the time of insertion into the cavity, and it remains below 7 even after 1 month. Relative to pulpal response, it is classified as a reverse irritant and often serve as the reference material to judge the potential of other materials to elicit a relatively severe reactions. Thus, a silicate cement restoration requires a greater need for pulp protection than other cements.

2. Zinc Oxide Eugenol

ZOE is the least irritating to the PD organ of all intermediary base materials. If mild irritation is generated, it is due to the eugenol or to imparities within it.

3. Zinc Phosphate Cement

Due to the presence of the phosphoric acid, the acidity of the cement is quite high at the time when a prosthesis is placed on a prepared tooth. Two minutes after the start of the mixing, the pH of $Zn_3(PO_4)_2$ cement is approximately 2 and increased rapidly but still is only about 5.5 at 24 hours.

Any damage to the pulp from acid attack occurs, probably during the first few hours after insertion. Studies of $Zn_3(PO_4)_2$ containing radioactive H_3PO_4 indicate that in some teeth the acid from the cement can penetrate a dentin thickness as great as 1.5 mm.

4. Glass Ionomer Cement

The glass ionomer cements bond adhesively to tooth structure, and they inhibit infiltration of oral fluids at the cement tooth interface. This particular property plus the less irritating nature of the acid should reduce the frequency of post operative sensitivity.

When postoperative sensitivity does occur, it is likely that one or more conditions may exist. These conditions include a preexisting pulpitis, a particularly deep cavity preparation and associated minimal dentin thickness that reduces the time for diffusion of irritants to reach the pulp, and bacterial invasion along the tooth cement interface.

The smear layer on the cut surface of the cavity preparation should not be removed but should be left intact to act as a barrier to the penetration of the tubules by the acid to component of the cement. All deep areas of the preparation should be protected by a thin layer of a hard setting calcium hydroxide cement.

4. Calcium Hydroxide Cement

This material initiates reparative dentin formation provided there is an effective depths of 100 micrometers.

If it comes in contact with the root canal tissues, the layer of tissues that it contacts directly will undergo chemical necrosis followed by calcific bridge formation by odontoblasts. It is often used as a cavity liner.

5. Polycarboxylate Cements

It is minimally irritating to the PD organ. The irritating ingredients, if present, may be the exothermic heat of the polymerization reaction, porosity and to some extent, the polyacrylic acid in deep cavities. Although the pH of the setting cements is the range of 1.5 for the first day or so, it is minimally irritating to the P.D. organ. This is because of the giant dimensions of polyacrylic acid macromolecules and their attachment to the main bulk of the cement mass. The acid has low diffusion mobility into the underlying dentin due to its immediate complexing with dentinal fluoride, calcium and some osseous components. The complexed product will prevent further penetration of the acid.

Bleaching Agents

Bleaching agents have been used on non-vital and vital teeth for many years, but their use on vital teeth has increased dramatically. These agents usually contain some form of peroxide (generally carbamide peroxide) in a gel that can be applied to teeth either by the dentist or at home by the patient. The agents may be in contact with teeth for several minutes to several hours depending on the formation of the material. *In vitro* studies have shown that peroxide can rapidly (within minute) traverse the dentin and in sufficient concentration is to be cytotoxic. The cytotoxicity depends to a large extent on the concentration of the peroxide in the bleaching agent. In vivo, there are few studies that have demonstrated adverse pulpal effects from bleaching, but more reports agree that a legitimate concern exists about the long term use of these products on vital teeth.

Pulp Capping Agents (Biocompatibility)

Despite the growing success of CH in vital pulp therapy, considerable condemnation of this material have long persisted because CH in the pure state an in the original formulations actually killed a certain amount of tissue when placed in direct contact with the pulp rather than merely functioning as a biologic dressing.

Because of the recent adjustments made in the pH of calcium hydroxide, two modes of healing are now proposed. Because dentin bridge formation resulting from the original CH described for many years, and some present day products still maintain a high pH, it is appropriate to describe the healing loading to bridge formation under high pH conditions.

When a cement like pulpdent (CH and water is used) healing leading to bridge formation occurs at the junction of the firm, necrotic non-vital layer created by the caustic (high alkaline pH) CH agent that destroys 1 mm or more of pulp tissues. The bridge is readily visualized with the radiolucent pulpdent paste because the degenerated, necrotic zone separates the CH layer from the bridge. However, with the original Dycal material, the calcified dentinal bridge forms directly against the CH and is more difficult to observe radiographically.

Dycal produces the zone of coagulated necrosis similar to that produced by pulpdent but that is rapidly removed by phagocytes and replaced. Granulation tissue then quickly organisms, matures and differentiates odontoblasts to produce the dentinal bridge adjacent to the dycal.

Root Canal Filling Materials

Grossman grouped obturating materials into plastics, solids, cements and pastes. He indicated that an ideal root canal filling material should meet the following requirements:

1. It should seal the canal laterally as well as apically
2. It should not shrink after being inserted
3. It should be impervious to moisture

4. It should be bacteriostatic, or at least not encourage bacterial growth
5. It should not irritate periradicular tissue
6. It should not produce an immune response in periradicular tissue
7. It should be neither mutagenic or carcinogenic

Endodontic Procedures

Endodontic procedures involves removal of irritants from the root canal system and its total obturation to result in repair of the periradicular tissue to its normal architecture.

Although all root canal sealers leak to some extent, there is probably a critical level of leakage that is unacceptable for healing and that may result in endodontic failure. This leakage may occur at the interface of dentin and sealer, at the interface of the solid core and sealer, through the sealer itself, or by dissolution of the sealer.

Some sealers leak more than others mostly through dissolution. The broader the sealer periradicular tissue interface, the faster the dissolution with take place. Moreover, all sealers currently used shrink as well as the solid core filling materials, are eventually tolerated by the periradicular tissue once the cement have set.

If the apical orifice can be blocked principally by a solid core material success in immediately improved over time.

A sequence of events might well explain the paradox of the periradicular lesion associated with a noninfected pulpless tooth. Periradicular inflammation is pressured to persist under the influence of any noxious substance. Bacteria certainly play a major role in the production of these products in the root canal. However, in the absence of bacteria, degraded serum (leaking from the periaradicular tissue to partially filled canal), may well assume the role of the primary tissue irritant. If the canal is not filled perfectly, serum will seep into it from the apical tissues. With sufficient bacteria present, the situation worsens. The serum may furnish nutrient material for any microorganisms remaining in the tubules.

Apical Filling with Dentin Chips

To condense dentin chips deliberately constitutes a "new technique" or a biologic seal rather than a mechanical seal.

Such a "plug" can prevent overfilling and can restrict the irrigating solution and obturating material to the canal spaces.

Biocompatibility of Dental Ceramics as Implant Materials

Ceramics are inert, biocompatible material with low thermal and electrical conductivity and reduced plaque accumulation. Glazed porcelain surfaces offer a good finish.

Precautions must be taken when using hydrofluoric acid as it corrodes the porcelain. Protection which using APF gels is essential. Uranium powder in – corporate fluorescence is a health hazard.

Most ceramic materials used have very low toxic effects on tissues, either because they are in an oxidized state or are corrosion resistant. As a group they are non-immunogenic and non-carcinogenic.

Their disadvantages are that they are brittle, lack impact and shear strength.

These materials have been used as coatings on metals. These coatings have been used in either porous or dense forms. If the root surface porosites are over 150 mm in diameter, the implants often become firmly bone to bone (ankylosis, osseointegration). If the porosites are smaller, the tissue usually forms a fibrous ingrowth. Dense ceramics are also used as root replicas or bone screws. Made of either single crystals (sapphire) or polycrystalline Al_2O_3, they become osseointegrated and provide excellent stability if left unloaded for a time. In one study 60% of the restorations still performed adequately after 6 years in place.

Hydroxyapatite, a relatively nonresorbable form of calcium phosphate, has been used with some success in coating material for titanium implants as ridge augmentation material. Studies indicate that hydrocyapatite increase the rate of bony ingrowth towards the implant. However, the long-term corrosion of these coatings and the stability of the bond of the coating to the substrate is still controversial.

Beta tricalcium phosphate has been used in situations where resorption of material is desirable, such as repair of bony defects.

Carbon has also been used as a coating and in bulk forms for implants.

Finally bioglass forms a surface gel that reacts favorably with connective tissue allowing bone formation adjacent to it.

Carbon is inert and corrosion resistant and cells and tissue adapt well to the surface which allows normal differentiation of surrounding tissues.

Reactions to Metals and Alloys

Reactions to nickel and beryllium have already been mentioned. So has been mentioned the very rare adverse reaction to gold.

Stainless steel was used a great deal in the past because it is in expensive, easily available and strong. In addition, it can be cast or wrought, which means it can be fabricated into many forms such as endorted blades and ramus bars.

However, it is very susceptible to corrosion in a saline environment such as tissue fluid. With corrosion it undergoes metal fatigue, a major reason for failure of an implant. Furthermore, it is believed that corrosion products that are released can cause adverse inflammatory reaction, which discourages osseointegration and promotes fibrous capsule formation.

Cobalt – chromium – molybdenum are also castable and was previously the mainstay of the metallic implants. However, this also presents the problem of fibrous capsule formation. Studies have shown that these elements accumulate locally and in systemic organs such as lung, liver and kidney. However, controversy remains over this issue.

Titanium is a pure metal, at least when first cast; within short time (less than a second) the surface forms a thin film of titanium oxide, which is corrosion resistant and allows bone to grow to within 100Å of implant. The major disadvantage of this metal is that it is difficult to cast.

It has been wrought into endosted bladders and root forms, but this process introduces metallic imparities into the surface that may adversely effect bony response unless extreme care is taken during manufacturing.

Although Titanium and Titanium alloy (i.e. Titanium aluminium), Vanadium, have corrosion rates that are markedly less than other metallic implants, they do release titanium in the body.

Condensed Gold Foil

Cause a moderate to severe inflammation. Response may be caused by trauma of condensation during placement. Changes are not irreversible and reparative dentin may form under these restorative materials. The use of cohesive gold is considered biologically sound. Gold foil shows least microleakage.

Effect of some other Materials used in Dentistry

1. Cyanide solutions used as an electrolyting for electroplates for the formation of electroformed dies prior to casting of metallic restorations should be handled with extreme care as it is called 'death chamber gas' and may be fatal if care is not taken.
2. Asbestos ring liners during casting have been reported to be non-biocompatible.
3. Silica used in investment materials is capable of causing silicosis (Grinder's diseases) which may cause lung cancer.
4. Fluoride containing fluxes are likely to attack porcelain if fused for presoldering.
5. Dentifrices act by:
   a. Abrasive and detergent action providing efficient removal of debris; plaque stained pellicle
   b. Polishing teeth hence increasing shine to enhanced light reflectance
   c. Desensitizing teeth if they contain strontium chloride and potassium nitrate
   d. Preventing caries if they contain fluorides and also promoting remineralization.
   e. Controlling tartar if they contain potassium and sodium pyrophosphates.

However, their abrasive action may lead to loss of tooth structure.

CONCLUSION

The biocompatibility of a dental material depends on the compositions of the material and the location and interactions of the material in the oral cavity. Metal ceramic and polymer materials all elicit different biological responses, because of their difference in composition. Furthermore, diverse biological responses to these to these materials depend on whether they release their components and if those components are toxic, immunogenic or mutagenic at the released concentrations. The location of a material in the oral cavity also partially determine its biocompatibility. Materials that appear biocompatible when in contact with the oral mucosal surfaces may cause adverse reactions if they are implanted beneath it. Materials that are toxic when in direct contact with pulp may be essentially innocuous if placed on dentin or enamel. Finally interaction between the material and the body influence the biocompatibility of the material. The material's response to changes in pH, the application of force, or the degenerative effects of the biological fluids can alter its biocompatibility. Features of a material's surface that promote or discourage the attachment of bacteria, host cells or biological molecules determine whether the material will promote plaque retention, integrates with bone or adhere to dentin.

12 Patient Assessment, Examination, Diagnosis and Treatment Planning

Pretreatment considerations consisting of patient assessment, examination and diagnosis, and treatment planning are the foundation of sound dental care.

Any patient who desires dental care requires a systematic approach to the arrival at a diagnosis and the formulation of a treatment plan.

Three pretreatment considerations—medical review, examination and diagnosis are necessary during each of the initial, emergency, re-evaluation and recall visits. Regardless of the type of visit, however, the dentist must routinely evaluate the patients systemic condition, along with the status of the teeth, periodontium, occlusion and facial structures.

Pretreatment assessment must be thorough and systematic. The results of this assessment must be recorded accurately in the patient record which is maintained for proper patient care and for medical/legal and forensic purposes.

PATIENT ASSESSMENT

Vitals

1. Name
2. Age
3. Sex
4. Address

Chief Complaint

The prime reason for which the patient seeks to consult the doctor is known as the chief complaint. It could be:

1. Pain
2. Swelling
3. Cavitation
4. Esthetics
5. Difficulty in mastication
6. Routine dental check up
7. Food impaction
8. Sharp tooth.

Details of the Chief Complaint

i. *History of pain*
   - Duration of pain
   - Localized/diffuse
   - Intensity of the pain, whether it is sharp, piercing or dull and grawing. In a case of acute pulpitis sharp pain is present as compared to irreversible pulpitis in which a dull, lingering pain is present.
   - Is the pain continuous or intermittent with asymptomatic periods in between?
   - Are there any associated symptoms such as fever etc.?
   - What are the precipitating and relieving factors?

- Any association with pressure or mastication.
- Does the pain radiate?

ii. *History of swelling*
- What is the duration of the swelling?
- Was the swelling preceded by an erythema or trauma?
- Is it tender/non-tender?
- Is it hard, soft or fluctuant in consistency?
- Is there any relation to meals – does it increase before meals?

iii. History of cavitation
- When was the cavitation first noticed?
- Is there any pain associated with it?

iv. Esthetics
- Since when have the teeth become unesthetic?
- Did the patient notice it himself or was pointed out by friends/relatives?

v. Difficulty in mastication
- Since when has the problem being going?
- Is there problem with any particular type of food, whether hard or soft?
- Is there any pain? – if so what is the nature of the pain.
- Is the difficulty in mastication unilateral or bilateral?
- Is the problem associated with a single tooth or generalized?

vi. Food impaction
- What is the duration of the problem?
- Is there any foul odous associated?
- Is there any pain associated with it?

vii. Sharp tooth
- Since when has the tooth been hurting the patient?
- Was it initiated after biting on a hard object?
- Did it appear after getting a restoration?
- Is it causing trauma to the side of the tongue, cheek etc.

viii. Routine dental check-up
- Quite a few patients come to the dentist for a routine dental check up without any particular problem.
- They come either on their own or accompanying an appointed patient or patient with a specific complaint.

Once the details of the current dental problem are known, the next step is to go on with the history taking.

History Taking

It is the procedure of asking questions from the patient in an orderly and systematic way.

A. *Prenatal history*

In this questions are asked about
- Birth–whether it was a normal delivery or Caeserian section.
- Whether the baby was premature or full term.
- Status of nutrition of the mother during pregnancy.
- Was there any rediation exposure of the mother.

B. *Postnatal history*

Inquire for
- congenital defects
- any pressure habits
- oral habits
- bottle fed/breast-fed.

Family History

It is important to ask for any positive history of a disease that runs in the family.

Medical History

It helps to identify
1. Communicable diseases that require special precautions, procedures or referral.

2. Allergics or medications that may contraindicate the use of certain drugs.
3. Systematic diseases and cardiac abnormalities prophylactic antibiotic coverage.
4. Physiological changes associated with aging that may alter clinical presentation and influence treatment.

Some conditions of interest are:

Rheumatic Fever

In a patient with rheumatic fever SABE can occur after any bacteremia which occurs even with slightest of manipulation.

Thus in such patients an antibiotic cover must be given in the 1st appointment and in subsequent appointments if bacteremia is suspected then.

Penicillin vs. orally 2 gm given 1 hour preoperative followed by 1 gm after 6 hrs is recommended.

In patients allergic to penicillin we give 1 gm erythromycin 1 hour preoperative followed by .5 gm postoperative after 6 hours.

Artificial Heart Values

In such patients, an antibiotic prophylaxcs is required since these artificial values act as excellent sites on which the bacteria can lodge and form vegetations. Once there is a transient bacteremia.

Coronary Artery Disease

These are patients who are usually on or anticoagulant therapy so in such cases a non-surgical approach should be preferred. Main aim should be to reduce anxiety to the minimum.

We can either:
- Use tranquilisers to reduce anxiety.
- Give short morning appointments.
- Analgesics given during treatment.

Hypertension

It can occur separately or in conjunction with a cardiovascular disease.

Efforts should be aimed at:
1. Giving short early morning appointments.
2. Decrease anxiety by giving some sedative.

Diabetes

Diabetics have retarded wound healing and are more susceptible to infections, thus
1. Antibiotic prophylaxis of penecillin V-1000 mg 1 hr. prior to appointment and 500 mg.
2. Appointments should be after meals preferably in the morning.

Hepatitis: Since such patients have impaired hepatic function drugs that are detoxified by the liver should be avoided such as erythromysin. Apart from this if there is a known history of hepatitis, barrier technique should be reinforced.

Hemophilia: In such patients due to a deficiency of factor VIII, the patients bleed even with the slightest blow so surgical procedures as extractions are contra-indicated.

Even a block is avoided as it can lead to internal bleeding.

RCT is performed in such patients by first minimyfying the entire pulp and then exterpating it out. Rubber dam is also applied with caution as its clamps may impinge the gingiva, thus notches are made on the teeth.

Syphilis

Such patients are highly infectious in the secondary stage which has snail brack ulcers in the oral mucosal. Thus, the operator should take care to protect himself.

AIDS

In such patients

- Operator must adopt all barrier technique (preferably with double gloves)
- Tooth should be swabbed with 5% NaOCL which should also be used for irrigation.
- Same should be used for cleaning the rubber dam also.

Phychological Problems

Such patients could be:

1. Those who feel that they have symptoms of some disease but actually are without any. Such patients need to be reassured and put on antianxiety drugs.
2. Those who have fears and anxiety which make treatment difficult.
3. Those who actually have a psychiatric problem.

Dental History

Past Dental History

- The patient should be asked about previous visits to the dentist, whether the patient went only when he felt pain.

  If examination reveals many edentulous spaces, heavy calculus, obvious carious lesions and minimal restorations it gives an impression that sophisticated dental procedures will not be successful.
- However, if the patient has edentulous spaces replaced with a poor prosthesis it indicates that the patient has a deserve for good dentistry but has been unable to get it.
- Patient should be asked whether he was satisfied or not with the treatment.
- Was there any relief for the problem he was having.
- Any reaction to local anesthesia.
- Any history of extraction complication.

CLINICAL EXAMINATION

This consists of an orderly set of events that lead to observation of the conditions prevailing and then formulating a diagnosis. It essentially consists of 2 parts:

i. Examination
ii. Diagnosis

Examination: It is the hands on process of observation of both normal and abnormal conditions.

Diagnosis: It is the determination and judgment of variations from normal.

Examination is divided into 2 parts:

A. Extraoral examination
B. Intraoral examination

Care should be taken not to overlook any steps of examination.

Extraoral Examination

This is basically done by

- Visual examination
- Palpation

This examination involves checking for the following:

1. Jaw symmetry
2. Facial symmetry:
   a. hemiatrophy
   b. hemihypertrophy
3. Any extraoral sinus
4. Closure pattern, lateral and protrusive movement
5. Any swelling, tenderness of TMJ, any clicking or snapping

Intraoral Examination

This includes a sequence of steps, which should be followed in order to reach a correct diagnosis.

1. Visual examination
2. Tactile examination
3. Palpation
4. Percussion
5. Transillumination
6. Selective anesthesia
7. Dental floss
8. Caries detector
9. Caries meter
10. Pulp vitality tests
11. Radiographs
12. Diagnostic casts
13. Lasers Doppler flowmetry
14. Nd: YAG lasers

Visual Examination

Oral Hygiene

This is the first thing to be noticed when the intraoral examination begins:

It reflects:

– Patients attitude towards his oral health.
– Home care habits.
– Motivation.

If the oral hygiene is poor, we avoid

i. fixed prosthesis
ii. expensive restorations

Since there are greater chances of recurrent caries, thus for anterior restorations, silicate cements are used due to their anti caries property and a reasonable average life.

Expensive restorations can be given afterwards when the patients oral hygiene shows an improvement.

Any Prosthetic Appliance

The presence or absence of any prosthetic appliance in the mouth indicates as to how much the patient is bothered about oral health. If there is a removable partial denture or teeth have been extracted indicates that the patient is indifferent to oral health.

Soft Tissue Lesions

This involves checking for the oral manifestations of various infections as herpes, measles, hepatitis, infectious mononucleosis etc.

It also includes checking for

– vitamin deficiencies
– oral ulcers
– sinus in relation to a particular tooth
– gum or pulp polyp
– lichen planus
– masochistic habit
– oral submucous fibrosis

Type and Amount of Saliva

Saliva is the best protective mechanism the oral cavity has to offer.

If saliva is not present in sufficient amount as in erostomia its cleansing action is absent.

Such a condition is seen when there is partial atrophy of the salivary glands, which leads to xerostomia, causing stagnation of food. This leads to caries especially in the cervical areas or areas which are normally cleaned by saliva.

In diseases such as Sjögren's syndrome, multiple caries especially at the cervical enamel was seen due to demineralization of enamel, resulting in rampant caries within a period of 2 years.

Occlusion

Checking of the current occlusal scheme of the patient leads to detection of

a. Premature contacts: These could be a trigger factor for bruxism.
b. Traumatic occlusion: can be checked by placing a finger on the labial surface of anterior teeth and patient to close the mouth.

Any vibrations felt on the finger lead to a detection of traumatic occlusion.

c. Conditions leading to bone loss.
d. Impact of proposed restorative treatment on the occlusion.
e. Effect of current occlusal scheme on the proposed restorative treatment.

E.g. if the patient has bruxism, porcelain restorations will not be advised.

Edentulous Spaces

The presence of edentulous spaces indicates that the patient is not conscious about his oral health.

Periodontium

Depth of gingival sulcus is 1-2 mm buccally and lingually and 2-3 mm interdentally.

– Any gingival recession should be noted
– Any mobility
– Hemorrhage or exudates from periodontal pocket.

Healthy gingiva is coral pink, knife edged, scalloged, firm and stippled. Its gingivitis, soft, oedentitous, glazed smooth surface is present.

A variety of causes can lead to such a condition as

i. Overhanging restorations
ii. Rough restoration
iii. An unfilled carious restoration in the proximal area which leads to food accumulation causing gingivitis and subsequently periodontitis.

Dentition

This should be checked for:

a. Contour
b. Size, form, structure and number
c. Proximal contact relationships
d. Erosion, abrasion and attrition
e. Fracture of tooth
f. Color
g. Carious lesions
h. Restorations

a. *Contour:* If dentition is undercontoured, it leads to more retention of plaque due to thicker gingiva margins – on the other hand, over contours lead to plaque accumulation as self-cleansing action of gingiva is disturbed. Moreover stimulation of the gingiva by the food is also disturbed.

b. *Size, form, structure and number:* The size of the restoration should be proportional to the size of the teeth. An oversized restoration during the mixed dentition period may impede proper eruption of the underlying tooth.

Undersized restoration can on the other hand lead to an undesirable shift in tooth alignment.

The number of teeth present should be noted. There are some teeth that could be missing congenitally as max LI, Md 2nd premolars etc.

There could be

– Partial anodontia
– Complete anodontia
– Multiple missing teeth due to caries or periodontal problems.

If teeth are congenitally missing the spaces may be closed orthodontically, and if teeth have been lost due to caries, a caries preventive program should be initiated. The structure of the tooth could be defective. There could be hypoplasia or hypomineralization. Proximal contact relationship–seen by (i) visual examination (ii) dental floss. When the dental floss is inserted it should go in a snap and should not come out sudden.

Erosion: It is the loss of surface tooth structure by chemical action in the continued presence of demineralizing agents (acids). The resulting defect is smooth, crescent or dish shaped on the surfaces of exposed teeth particularly by exogenous acidic agents as lemon juice or other citrus fruits etc. Endogenous acidic agents as gastric fluids cause generalized erosion on the lingual, incisal and occlusal surfaces.

Abrasion: It is the abnormal tooth surface loss resulting from direct frictional forces between teeth and exertional objects.

It usually caused by improper brushing techniques, holding a pipe stem between teeth tobacco chewing or chewing of hard objects as pens or pencils. Presents as sharp wedge shaped notch in the gingival portion of facial aspects of teeth surface is smooth, and treatment is aimed at removing the cause.

Attrition: It is the mechanical wear of the incisal or occlusal structure as a result of functional or parafunctional movements of the mandible. Although a certain degree is expected with aging, abnormal attrition should be checked, and if present enquiry should be made into the habits/functional movements to eliminate this grinding/ bruxism.

Fracture or Craze line: They are often visible, especially with advancing age and are thought to be potential cleavage planes for possible future fractures. Appropriate dye materials or light reflected from a mirror can aid in detecting them, biting on a rubber wheel/cotton roll can also help to diagnose it.

Carious Lesions

1. Opacity of the tooth when it is dry is diagnostic of caries. An opacity that is present on the tooth surface when the tooth is either dry or wet is a hypoplastic lesion.
2. Cavitation present on the tooth.
3. Discoloration of marginal ridges or brown gray discoloration radialing peripherally from a fissure/pit.

Restorations

Amalgam, though an excellent restorative material undergoes a variety of discrepancies. Depending on their severity these restorations should be replaced.

At least ten different conditions can be uncountered with respect to amalgam restorations. They could be:

i. Amalgam blues
ii. Proximal overhangs
iii. Marginal ditching
iv. Voids
v. Fracture lines
vi. Interface lines
vii. Improper anatomical contours
viii. Marginal ridge incompatibility
ix. Improper proximal contacts
x. Recurrent caries

They are briefly discussed as :

1. *Amalgam Blues:*
   - Discolored areas seen through enamel in teeth with amalgam restorations.
   - Bluish have results from either leaching of corrosion products of amalgam into dentinal tubules or from color of underlying amalgam as seen through translucent enamel.
   - When other aspects of the restoration are sound, amalgam blues are not indicative of caries and do not label the restoration as being defective.
2. *Proximal overhangs:*
   - Diagnosed visually, tactilely and radiographically.
   - Amalgam tooth junction is evaluated by moving the explorer back and forth

across it. If the explorer stops at the junction and then moves outwardly.
- Onto the amalgam an overhang is present.
- Overhangs can also be detected and confirmed by catching or tearing of dental ghess.
- Such an overhang acts as a plaque trap, providing an obstacle to good.
- Oral hygiene and usually results in inflammation of adjacent soft tissues.
- It should be corrected and indicates replacement of the defective restoration.

3. *Marginal gap or ditching:*
   - Results from deterioration of the amalgam tooth interface on the occlusal surfaces as a result of wear, fracture, or improper cavity preparation.
   - Can be diagnosed visually or by the explorer dropping into an opening as it crosses the margin.
   - Shallow ditching less than 0.5 mm deep does not usually need a replacement.
   - Self-sealing property of amalgam allows the restoration to continue serving adequately if it can be satisfactorily cleaned.
   - If the ditch is too deep to be cleaned or jeopardizes the integrity of the remaining restoration or tooth structure, it should be replaced.
4. *Voids:*
   - Occur at the margins of amalgam restorations.
   - If it is at least 0.3 mm deep and located in the gingival one-third of the tooth crown, the restoration is termed as defective and should be repaired.
   - Accessible small voids in other marginal areas where enamel is thicker may be corrected by recontouring or repairing with a small restoration.
5. *Fracture lines:*
   - Seen across occlusal portion of an amalgam restoration.
   - A line occurring in the isthmus region indicates fractured amalgam needing a replacement.
6. *Interface line:*
   - Seen as a line in the mid occlusal area which is a manifestation of two abutted restorations, each done at a separate appointment. If other aspects of the abutted restorations are satisfactory, replacement is not required.
7. *Improper anatomical contours:*
   Restorations that impinge on soft tissue, have inadequate embrasure form or proximal contact or prevent the use of dental floss are defective and indicate replacement.
8. *Marginal ridge incompatibility:*
   Ideally both ridges should be at approximately the same level and display correct occlusal embrasure form for passage of food to the facial and lingual and for proper proximal contact area. If the marginal edges are not compatible and are associated with poor tissue health, food impaction, or the inability to floss, the restoration is defective and should be recontoured or replaced.
9. *Improper proximal contacts:*
   Ideally an amalgam restoration should form a 'closed' contact with the adjacent tooth at the proper contact level.

   If any restoration contact is suspected to be inadequate it should be evaluated by dental floss and/or by angulation of a mouth mirror to reflect light.

   An 'open' contact is very distressing and should be corrected.

10. *Recurrent caries:*
    Present at the margins of the restoration.

Palpation

It is done with the tip of index finger using light pressure. The finger is gently passed in the microbuccal fold to look for any swelling. The swelling could be either hard or soft.

Palpation also reveals lymphadenspathy.

Tactile Examination

Tactile examination is done for

i. Periodontium–to determine the presence of a periodontal pocket.
ii. Restoration–when an explorer is passed from the tooth to the restoration the transition should be smooth and the explorer should not jump at the tooth restoration interface.
iii. Teeth–tactile examination is done to determine the presence of caries.

    The explorer is placed in a fissure and if it provides resistance or a tug-back when it is tried to remove from the fissure, the fissure is said to be carious.

Mobility/Depressibility Test

It is basically done for the evaluation of the attachment apparatus of the tooth. The tooth is moved laterally in the socket by the fingers or handless of the instrument.

Percussion Test

It is done to evaluate the integrity of the periodontium.

The suspected tooth is not struck at first. We begin by percussing the adjacent teeth first. The tooth is struck with a quick moderate flow with the handle of the instrument.

A sensitive response differs from response of adjacent teeth which is determined by the reflex action of the eyes which is the case in periodontitis. If no pain is elicited, infection lies in the pulp only.

Transillumination or Fibreoptics

Ideally in a dark room, a light source is placed on the lingual surfaces of the teeth proximal surface caries other than incipient lesions shows as a dark area along the marginal ridge when light is reflected through the tooth.

In teeth with necrotic pulp the shadow of the pulp canal space will appear darker than the rest of the tooth.

In case of a vertical fracture if the fiber optic light is passed at right angles to the fracture line the segment of the tooth on the side of the crack will illuminate while the other side will remain dark.

Radiographs

Dental radiographs are an indispensable part of the dentists diagnostic armamentarium radiographs are indicated for:

1. Previous periodontal or root canal therapy.
2. History of pain or trauma.
3. Dental anomalies
4. Periodontal disease
5. Large or deep restorations
6. Deep carious lesions–occlusal–proximal–root
7. Malposed or clinically impacted teeth
8. Swelling
9. Mobility of teeth.
10. Fistula or sinus tract infection
11. Growth abnormalities
12. Oral involvement in known or suspected systemic diseases
13. Foreign objects
14. Pulp calcification

Test Cavity

If by all the tests mentioned no diagnosis can be reached. We prepare a cavity in the tooth by using a bur without an anesthetic lack of sensitivity (response) when dentin is cut may indicate a non vital pulp. Sclerosed dentin, can also result in a false negative result.

Moreover, on multirooted teeth, one region of the dentin may respond, whereas another site may not, indicating pulp degeneration.

Selective Anesthesia

Normally the pain does not cross the midline or quadrant or the arch. In some situations the patient cannot distinguish or localize the pain, so in such cases selective anesthesia can be given to localize the lesion.

Electronic Caries Detector–Cariesmeter

It is a device which is used to check the electrical impedence of the tooth structure. It measures the electrical resistance of tooth when intact and also when porus due to cavitation.

Caries (Detector)–Dyes

For detection of caries earlier 0.5% basic fuschin was used. Since it proved to be carcinogenic it has been substituted by propylene glycol.

Later, 1% acid red in propylene glycol has been advocated for use since it stains the altered collagen, hence stains only the infected dentin.

Dyes can also be used for staining a crack in case of a tooth fracture. Vegetable dyes are most commonly used for this purpose.

Pulp Vitality Tests

This is actually a misnomer because the vitality depends upon the blood supply and by these tests we check for the nerve supply of the tooth two types of tests are available.

1. Thermal
2. Electrical

Thermal tests are of 2 types— a. hot b. cold.

Heat Test

The area is isolated and warm water, warm burmisher, warm compound or warm gutta perch which has just started giving fumes is placed in the contralateral tooth so that the patient can compare the response in the involved tooth. Then it is applied on the involved tooth.

Exaggerated response is found in hyperemia, acute pulpitis and also in cases of liquifaction necrosis.

Delayed response is obtained in chronic pulpitis. No response is observed in chronic alveolar abscess, granuloma or cyst.

Cold Test

The method of application is the same. We use either ice cubes/pencils of ice, ethyl chloride spray or ethyl chloride liquid that is applied on a cotton pellet.

It is tested first on the incisal third first and if there is no response, on the middle third and lastly on the cervical third.

In the cervical 3rd pulp is closer to the surface since the thickness of enamel and dentin is thinner and if heat is directly applied to this area there are chances of damaging the pulp.

Electric pulp tester: It is an instrument which uses grading of electric current to elicit a response from the pulpal tissue.

Uses

- vitality testing
- in differentiating periodontal from periapical diseases.
- In differentiating anatomical landmarks from areas of periapical pathosis.
- In endodontic treatment to see if pulp is completely anesthetized.

Interpretations

1. An exaggerated response is obtained in teeth with hyperemia and acute pulpitis.
2. A delayed response is obtained in chromic pulpitis.
3. No response occurs in necrosis, gangrene, periapical cysts, abscesses and granulomas.

Study Casts

These are used to formulate a treatment plan without the patient present along with clinical and radiographic findings, thus saving valuable chair side time.
They help in evaluation of
- Type of occlusion
- Plane of occlusion
- Tilted/extruded teeth
- Cross bites
- Plunger cusps/wear facets
- Proximal contacts
- Embrasures and spaces between teeth

Adjunctive Aids

Xeroradiography

This is an improved and advanced means of radiography. Its best benefit is the reduced amount of exposure needed for it; even inspite of this it produces a good deal of detail and accuracy.

RVG Radiovisuography

This is a sophisticated aid that displays the oral cavity, the area being worked upon on a screen which can be seen by the patient. Thus, the patient is aware of the treatment being performed.

OPG Orthopanteomograph

This consists of a single radiograph showing all the teeth including the temporomandibular joints on a single film.

Thus, with this technique a great reduction in the exposure given to the patient results.

EMG Electromyograph

This is a device that determines the relative action potential of a muscle.

It is used to diagnose conditions related to muscle tenderness as is seen in MPDS.

Laser Doppler Flowmetry

This is a device which is used to measure the blood flow into the tooth. Light is reflected onto the moving RBCs which backscatter the same light that is detected on a detector.

Lasers

He-Ne and Nd-YAG lasers are used for the diagnosis of carious lesions.

Treatment Planning

A treatment plan is a carefully sequenced series of services designed to eliminate or control etiolgocial factors, repair existing damage, and create a functional, maintainable environment.

An accurate prognosis for each tooth, for the patients overall dental health is central to a successful treatment plan.

The development of a treatment plan for a patient consists of four steps:

1. Examination and problem identification
2. Decision recommend intervention
3. Identification of treatment alternatives
4. Selection of the treatment with the patients intervention

Treatment Plan Sequencing

Complex treatment plans often should be sequenced control phase: This is meant to:

– eliminate pain
– eliminate active disease as caries/ inflammation
– remove conditions preventing maintenance
– eliminate potential causes of disease
– begin preventive dentistry activities the goals of this phase are to remove the etiological factors and stabilize patients health.

Holding phase: is the time between the control and definitive phases that allows for resolution of inflammation and time for healing. Home care habits are reinforced, motivation is assessed and initial treatment is re-evaluated.

Definitive phase: This involves some sort of definite treatment.

Maintenance phase: This includes recall examinations for:

– revealing need to prevent future breakdown
– reinforce home care.

CONCLUSION

Proper diagnosis and treatment planning play a critical role in the quality of dental care. Each patient must be evaluated individually in a thorough and systematic fashion. A successful treatment plant carefully integrates and sequences all necessary procedures indicated for the patient.

Examination, diagnosis and treatment planning are extremely challenging and rewarding for both the patient and the dentist if done thoroughly and properly with the patients best interests in mind.

13 Pin-retained Restorations

A pin retained restoration may be defined as any restoration requiring the placement of one or more pins in the dentin to provide adequate resistance and retention forms.

Pins are used whenever adequate resistance and retention forms cannot be established with slots, locks, or undercuts.

INDICATION FOR PIN-RETAINED AMALGAM AND DIRECT TOOTH COLORED RESTORATION

a. Pins are used as auxillary retentive means in restoring multilated and badly broken down teeth especially in young patients where the pulp chamber is relatively large, the dentinal tubules are comparatively immature and gingival lines are still high. The same reasons contraindicate massive tooth preparation for cast restorations.
b. Pins are used in restoring badly broken down tooth transitionally before endodontic or ortho treatment. In such cases pin retained restoration act as build up for rubber dam application or band attachments.
c. Pins are used as foundation for partial or full veneer crowns or metallic ceramic restorations.
d. Pins retained restoration is used as an economic provisional restoration for teeth with questionable prognosis endodontically and periodontically until definitive prognosis is established after some time.
e. Pins can be used as a mode of cross linkage between two bulky sound parts of remaining tooth structure which are separated by abnormal cracks.
f. Pins are uses as auxillary mode of retention for preparation with retentive modes which are insufficient to prevent displacement of the restoration in a direction.
g. Pins are used as a auxillary mode with part in endodontially treated teeth to prevent rotation of the restoration around the post in the root canal.

Advantages of Pin-retained Amalgam Restoration

a. Conservation of tooth structure as preparing pinholes are more conservative than slot or lock preparation and also it is more conservative than preparation for cast restorations.
b. Time for preparation is less compare to cast restoration. Pin retained restorations can be completed in one appointment whereas cast restoration requires at least two appointments.
c. Increased retention and resistance forms.
d. Inexpensive restorative procedure compared to cast restorations.

Disadvantages of Pin-retained Amalgam Restorations

a. Dentinal microfracture can occur during drilling pinholes and placement of pins. They are significant if minimal dentin is only present.
b. Microleakage around the pins.
c. Decrease in tensile strength of amalgam as pins do not reinforce restoration.
d. Difficulty to develop resistance form compared to preparation for an onlay.
e. Increased risk of perforation into the pulp or external tooth surface.
f. Sometimes proper contour and occlusal contacts are difficult to achieve.

TYPES OF PINS MATERIAL FOR AMALGAM AND DIRECT TOOTH COLORED

There are three types of pins (Figs 13.1A to C):
a. Cemented pins
b. Friction grip/friction lock pins
c. Threaded pins/self-threading pins

Self-threading pins are the one commonly used.

Cemented Pins

It was described by Markley in 1958. He used threaded (serated) stainless steel pins.

The pins used were either 0.025 or 0.020 inches and were cemented to pin channel 0.027 and 0.025 inches diameter respectively. (pin channels are larger in diameter than pin)

The pins are cemented using either zinc phosphate or zinc polycarboxylate cement.

Friction Locked Pins

Described by Goldstein in 1966. In this the pin holes are slightly narrower in diameter than the pin diameter (0.001 inch).

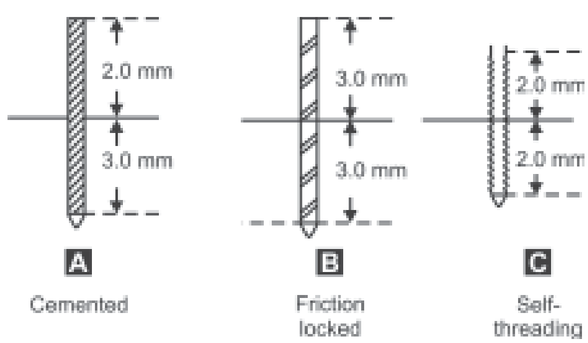
The pins taped to place and is retained by resilency of dentin. They are 2-3 time more retentive than cemented pins.

Self-threading Pins

Described by Going in 1966. In this type the pin channel is narrower than that of pin (0.0015-0.004). The pins come in four sizes.

Pin size (diameter) In inches	*Pin channel diameter*
0.031	0.027
0.023	0.021
0.026	0.018
0.015	0.013

The pins are retained by threads engaging the dentin as it is inserted. the resilency of dentin allows insertion of threaded pins into a smaller diameter pin channel.



Figs 13.1A to C: Different types of pins

The self-threading pins are most retentive of the three types of pins and is 3-6 times retentive then cemented pins.

DISADVANTAGES

a. When the pins are inserted lateral and apical stresses are generated in the dentin thus producing craze lines in dentine.
b. Pulpal stresses are maximum when self-threading pins are inserted perpendicular to pulp.

The depth of pinhole varies from 1.3-2 mm depending on the diameter of pin used.

THREAD MATING SYSTEM (TMS – PINS)

This is most widely used self-threading pins because

a. they versatile
b. wide ranges of pin sizes are available
c. color coding system for easy identification
d. good retention
e. gold plating reduces the chances of corrosion.

Regular (standard) – color coded gold
- Pin diameter 0.031 inch and channel diameter 0.027 inch
- Total pin length 7.1 mm; extending 5.1 mm into the dentin.

Regular (self-shearing) –gold
- Pin diameter 0.031 inch and channel diameter 0.027 inch
- Total pin length 8.2 mm; extending 3.2 mm into the dentin.

Regular (two-in-one) –gold
- Pin diameter 0.031 inch and channel diameter 0.027 inch
- Total pin length 9.5 mm; extending 4.7 mm into the dentin.

Mini standard – silver colour coded
- Pin diameter 0.024 inch and channel diameter 0.021 inch
- Total pin length 6.7 mm; extending 4.7 mm into the dentin.

Mini two-in-one – silver coded
- Pin diameter 0.024 inch and channel diameter 0.021 inch
- Total pin length 9.5 mm; extending 2.8 mm into the dentin.

Mini shearing – red color coded
- Pin diameter 0.019 inch and channel diameter 0.017 inch
- Total pin length 7.1 mm; extending 1.5 mm into the dentin.

Mini self-shearing – pink color coded
- Pin diameter 0.015 inch and channel diameter 0.135 inch
- Total pin length 6.2 mm; extending 1.0 mm into the dentin.

FACTORS AFFECTING PIN RETENTION IN DENTIN AND AMALGAM

The major objective of using pins in a restoration is to improve or acquire retention of the restoration in dentin. The factors affecting retention of pins in dentin are:

a. Type of pins — If the pins are of equal diameter and engage equal distance in dentin self-threading pins are 5-6 times more retentive than cemented pins. Friction grip pins are the next retentive ones with 2-3 times more retention than cemented pins.
b. Depth of pin engagement in dentin — Pin extension into dentin greater than 2 mm is unnecessary for retention and contraindicated to preserve the strength of dentin.
c. Shape of the pin channel relative to pin shape

   If there is greater coincidence between pin channel circumferential shape and pin shape, better will be retention as this will provide continuous contact between the pin and the dentin/cement.

d. Number of pins — Within limits, increasing number of pins increases retention in dentin. As the number of pins increases there will be crazing of dentin and there is potential for fracture. There will also be reduction of available dentin between the pins.

   Pins placed closer than 2 mm to each other in one tooth will lead to loss of retention in dentin as a result of microcracks created during insertion becoming continuous on function.

e. Type of cement — In case of cemented pins zinc phosphate cement (used only for non-vital teeth) is the most retaining cement. The retention of other cements in descending order are:
   Zinc phosphate cement
   Polycarboxylate cement
   Zinc oxide eugenol cement
   Use of varnish with zinc phosphate cement decreases retention.

f. Type of involved dentin — Young resilient primary dentin is most retentive followed by tubular secondary dentin. Hyper mineralization and dehydration decreases the retention in dentin.

g. Surface roughness of pins — Pins with threading or surface serration has increased retention especially in cemented pins.

h. Ratio of dentinal engagement of the pins and protruding length in cavity preparation.

   The ideal ratio is 2:1 increased ratio will increase retention whereas lower ratio decreases retention in dentin.

i. Mode of shortening of pins after insertion. Frequently it becomes necessary to shorten pins after they are engaged in dentin clipping the excess with cutting pliers is the least disturbing method. Using rotary instruments to cut excess can disturb the fit, thereby less retention.

j. Bulk of dentin around the pins. If greater bulk of dentin separates the pins from pulp, tooth or root surface greater will be the retention.

Factors Affecting Retention of Pins in Dentin Amalgam

a. Type of pins—Cemented pins and threaded pins are 4 times more retentive than friction and pins for amalgam because friction grip pins have smooth surfaces compared to threaded or gnarled surface of cemented and self-threading pins.

b. Pin length and engaging in amalgam—For friction grip pins retention is directly proportional to the length of pins in the restoration. For cemented and self-threading pins retention in amalgam is directly proportional to the length of the pin in amalgam upto a length of 2 mm.

   But for large threading pins the limit is 1.5 mm within the restorative material.

c. Pin diameter—There is gradual increase in pin retention in amalgam with increase in pin diameter upto 0.035 inch. Beyond this diameter there will not be any significant increase in retention.

d. Inter pin distance—Inter pin distance upto 2 mm will increase retention when the pins are brought closer to each other. Beyond this the retention will decline.

e. Proximity of the restorative materials—Greater the wetting ability of the restorative material to the pin surface the greater will be the adaptability thereby more friction so there is increase in retention.

f. Surface material of the pins—If the surface materials of the pins can chemical bond to the phases (mercury) there will be better retention, so silver veneering of pins contribute retention of some pins due to bonding with mercury. If gold plated pins are used, the gold should be pure and the pin surface is to be free of impurities to aid in reaction.

The Factor Affecting Stressing Capabilities of Pins

Stresses are induced in the dentin substance when pins are inserted. If these stresses exceed the elastic limit of dentin, permanent deformation occurs leading to microscopic and macroscopic cracks in the dentin. These cracks can lead to pulpal or external surface and/or periodontal involvement.

a. The factors that increase or decrease stresses during pin insertion are smaller the diameter of pin relative to diameter of pin channel there will be less amount of stress in dentin during pin insertion so maximum stresses are incorporated when friction pin is inserted.
b. Impact force during pin insertion can magnify the stresses.

   Threading pin technique induces less stress as the threadings sets dissipitate and consum some of the insertion energy by cutting part of the pin channel in the dentin.

   Moreover if the distance between the threads of pin threads are less more stresses will be concentrated in the dentin.
c. Diameter of the pins—Greater the diameter of pin more will be stresses induced into dentin.
d. Pin depth in dentin—More the depth of pin engagement more will be the stresses inducted.
e. Bulk of dentin—More the bulk of dentin pulpally or towards the surface for the pins less will be the amount of stresses per unit volume of dentin.
f. Type of dentin—Primary dentin are the least affected by stress induced by pins insertion due to high elasticity.

   Hypercalicified, sclerotic or dentin of non-vital tooth the dentin will not be able to tolerate stresses to the maximum.

   So in such cases of non-vital tooth (endodontically treated) only cemented pins are to be used. Likewise in tertiary dentin sclerosed dentin and calcified barrier areas threaded of friction lock pins are not to be used.
g. Interpin distance—More the distance between 2 pins less the possibility of stress concentration in the dentin beyond its tolerable limit.

   It is advisible to have a inter pin distance of at least 2 mm when small threaded pins are used. This distance should be increased if larger threaded pins are used or for function grip pins.
h. Shape of pin channel relative to pin shape—When the shape of the channel does not coincide with the pin shape the pin contacts the channel at one or two points only. So stress will be concentrated in these areas than all over the surrounding dentin.
i. Loose pins within the pin channel will be partially or completely motion which moves the restoration also. The energy created by these rotations will be precipitated as induced stresses within the dentin.
j. Abnormal shape of dentinal end of pins resulting from defective manufacturer or during pin adjustment prior to insertion will lead to concentration of stresses at small areas of dentin which may exceed the tolerable limit.
k. Number of pin per tooth per unit area of dentin. it should be minimum that is

required for retention to reduce stress concentration.

l. Method of drilling pin channel also alters stress concentration in dentin.

m. Over threading or over driving of pins in the pin channel can lead to stress within dentin.

n. Shortening of pins after insertion can induce stress in the involved dentin.

o. Bending or aligning pins after engaging in dentin will induces stresses.

p. Inserting pins at stress concentrating areas of the tooth like axial angle or incisal angle or at the junction of crown and clinical root will complicate existing stress patterns.

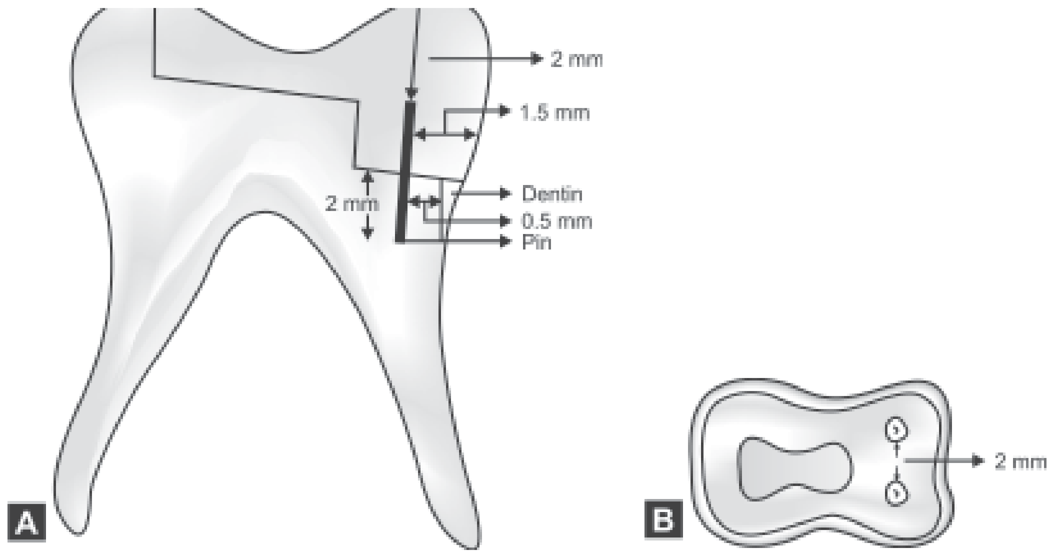
q. Lesser the other retentive features in the remaining portion of the cavity the lesser will be the displacing force entering through the pin so stresses are decreased.

Factors Aiding in Location of Position

a. Good knowledge of tooth anatomy and anatomy of inverting structure of tooth is basis for pin channel drilling without perforating or encroaching essential structures.
b. Radiographs aids in getting basic idea about dimension of dentin in 2 planes.
c. Outer surface of tooth next to proposed location of pins is a guideline for directing pin channels, e.g: pin angulation.
d. Amount of dentin present depends on pulp condition. Dentin dimension increases if pulp chamber or root canal is obliterated, likewise it decreases if there was any previous pathology or instrument during endodontic therapy.
e. Anatomical abnormalities if with surface like grooves and core cavities near the proposed location of pin increases the size of surface perforation.
f. Malalinged tooth needs individualized evaluation of tooth to determine the best access, location and angulation of pin channel.
g. Cavity extent of preparation also determines the location or pins. If gingival seat is more apical, more are the chances of surface or pulp/root canal perforation while channels are prepared.
h. Age of patients: As age advances there is increase in dentin, dimension as there will be decrease in size of pulp and root canal system.
i. Relative age of tooth: Dentin dimensions in first molar is greater than that of third molar.

Guidelines for Pin Placement (Figs 13.2A and B)

a. Pin should be placed as closely as possible to line angle of tooth because this area has greatest dentin bulk and are also areas where bulk of restorative material is placed.
b. Pinhole should be at least 0.5 mm from 5 mm DEJ to prevent crazing of dentin and fracture of external tooth surface.
c. When more than one pin are used, interpin distance should be at least 2 mm.
d. When more than one pin are used, pins are placed such that their axis are not parallel.
e. Pin should be at least 0.5 mm from axial wall of tooth to allow adequate condensation of restorative material around the pin.
f. For molars, one pin per missing cusp and for premolars two pins per missing cusp will provide adequate retention.
g. Whenever possible, smallest diameter pin is used.
h. Optimum length of pin extending into amalgam is two mm.



Figs 13.2A and B: Parameters for placement of pins

STEPS IN PIN-RETAINED (CLASS II AMALGAM RESTORATION)

1. *Patient education:* Discuss the treatment options with the patient.
   Explain the procedure and convey the possible complications during procedure. Convey the limitations of such restorations.
2. *Initial cavity preparation:* Obtain adequate anesthesia.
   Obtain occlusal outline form, proximal outline form and primary resistance and retention form.
3. *Final cavity preparation:* Excavate the remaining infected carious dentin and any previous restoration material.
   Provide pulp protection by liners and basis. Obtain additional retention and resistance form by means of locks, pins, and slots.

Locks are prepared in the axial line angle in longitudinal plane of dentinal wall has provisions for slots, make slots.

Pins: Select appropriate pin depending on
a. Amount of dentin available to receive pin safely.
b. Amount of retention desired.

In this system, pins of choice for severely involved posterior tooth are minikan and minim. Similarly regular pin should not be used because of large amount of stress and crazing on enamel created during insertion.

Select the number of pins to be used depending on:
a. amount of tooth structure available to receive pin safely.
b. Amount of missing tooth structure
c. Amount of retention required
d. Size of selected pins

As a rule, one pin per missing axial line angle should be used.

Fewest pin possible should be used to achieve desired retention for a given *restoration.*

* Locating pinholes using aids as mentioned before.

The pinhole should be located at least 1 mm from DEJ and 1.5 mm from external surface.

Before locating the area finally, probe gingival crevice to determine any abnormal contours that caused predispose to external perforation.

*After locating the pinhole use of ¼ bur and prepare a pilot hole (dimple) approximately ½ of diameter of bur at each location. This provides more accurate placement of twist drill and prevents crawling of drill.

Care to be taken while pinhole preparations and pin insertion:

a. Achieve correct angulation of the drill by placing drill first on the external surface in the gingival crevice adjacent to the pinhole location. Incorrect angulation can lead to perforation of external surface or the pulp exposure.
b. Don't tilt the handpiece while the pinhole is prepared as it leads to drilling of a large hole.
c. Don't stop rotating drill from time of insertion to removal in the pinhole to avoid breakage of the drill in the hole.
d. Don't use dull drill to prepare pinholes.
e. Use a throat shield/rubber dam if a hand wrench is used for pin insertion. Dental floss is tied to the hand so that to prevent swallowing or aspirating the band wrench if it falls accidentally.
f. While cutting excess pin never apply the bur parallel to the pin as it can turn the pin, anticlockwise and loosen it.
g. Apply steam of air to the bur at the pin junction while pin excess is cut off.
h. Don't bend the pins for making it parallel or to increase their retentiveness.
i. Never use sharp or other cutting instruments to bend the pin as it can cause fracture of dentin as the fulcrum will be at the mouth of pinhole. It can also lead to sharp bends.

4. *Finishing external enamel walls:* An enamel margin with cavosurface angle less than 90 is to be corrected. Remove any unsupported enamel if present.
5. *Final procedures:* Rinse the preparation if indicated with air/water spray.
   Dry to remove visible moisture.
   Apply cavity varnish in 2 layers. Now dentin bonding agents can also be applied.
6. Matrix placement
7. **Condense amalgam and initiate carving** after overfilling the preparation.
8. **Remove the matrix, retainer and wedge** without fracturing the restoration.
9. **Develop facial and lingual contours** with a carver. Sometimes it may be necessary to use rotary instrument to complete occlusal carvings if amalgam has set to hardness.
10. Evaluate margins and correct any discrepancies
    If the proximal contact is not adequate it can be corrected by preparing and ideal proximal cavity preparation within the pin amalgam and again restoring it.
11. **Pass dental floss** through the proximal contact and remove any amalgam shavings on the proximal surface of the restorations.
12. **Finishing and polishing** is done after 24 hours using pumice slurry.

Matrices for Pin-retained Class II Amalgam Restoration

Developing a satisfactory matrix for restoring a severely involved posterior teeth is very difficult.

Three types of matrix bands can be used for this purpose –

1. Universal matrix
2. Compound supported copper band matrix
3. Automatrix

In case of universal retainer if the open end of the tofflemaire is located next to the prepared tooth structure, a strip of matrix long enough to extend from distal to mesial end of tooth is cut and inserted between the matrix band and the tooth. Tighten the retainer as such or condense small amount of softened compound between the strip and open aspect of the band to stabilize the strip.

Compound Supported Copper Band Matrix

This can be used when there is very little tooth material remaining and tofflemaire cannot be applied successfully.

A seamless copper band is selected depending on the fit on the circumference of the tooth and touching the proximal surface of adjacent tooth.

Feston the gingival end with curved crown and bridge forceps to correspond it to the level of gingival attachment. Smoothen any round edges and contour the cut end with no. 114 contouring plier.

Place the band and adjust the gingival end until the band extends 1 mm past the gingival margin. Contour the proximal, facial and lingual aspects of the band.

Scribe a line in the outersurface of the band to indicate a correct occlusal height. This line should be 1-2 mm above the marginal ridges of adjacent teeth and should be above the occlusal height in all surfaces.

Remove the band, cut the band along the line with the scissors. Smoothen any rough surface by sand paper or mounted rubber wheel.

Reduce the thickness of the band proximally without perforating it.

Place the band and reinsert the wedges. Using contouring pliers adapt the band to tooth. Apply compound to stabilize the band and improve adaptation.

Slightly burnish the prepared cavity to ensure that no compound is between the band and the adjacent tooth.

After carving, break the compound with a explorer and remove the band by cutting grooves on the facial or lingual surface with a bur and remove the 2 sections occlusso-gingivally or occlusofacially.

Automatrix: These retainers can be applied to any tooth regardless of the circumference. The bands can be 3/16, 1/4 or 5/16 inches. Tighten the selected band around the tooth and condense amalgam.

14 Extracoronal Cast Metal Restorations

INTRODUCTION

Extracoronal restorations are defined as restorations which use a veneer to restore external portions of a prepared tooth to tissue compatible contour and obtain retention and resistance to displacement primarily from the fit of the restoration to the external walls of the preparation.

These may include all metal, all ceramic, combination of metal and ceramic and combination of metal and resin.

Extracoronal cast metal restorations are the restorations of choice in cases of extensive cases, fracture of tooth. Traumatic dentition and in areas where greater than average occlusal forces are present.

These restorations are doomed to failure if proper cause selection is not done if the tooth preparations are not based on sound biomechanical principles.

This chapter is an attempt to highlight principles of tooth preparation of different cast metal extracoronal restorations.

Principles of Tooth Preparation

Mechanical Consideration

The design of preparation for a cast restoration and the execution of that design are governed by four principles:
1. Preservation of tooth structures
2. Retention and resistance
3. Structural durability
4. Marginal integrity

Preservation of Tooth Structures

In addition to replacing lost tooth structure, the restoration must preserve the remaining tooth structure. Intact surfaces of tooth structure which can be maintained while producing a strong, retentive restoration should be saved. Based on this philosophy premise, some form of partial veneer restoration is the design of choice.

Retention and Resistance

For the restoration to accomplish its purpose, it must stay in place on the tooth. No cements which are compatible with tooth structure and the biologic environment of the oral cavity possess the adhesive properties required to hold a restoration in its place. As we should rely on the geometric configuration of the tooth preparation to provide the necessary retention and resistance.

Retention prevents removal of the restoration along the path of insertion or long aim of the tooth preparation.

Resistance prevents dislodgement of the restoration by forces directed in an apical or oblique direction and prevents any movement of the restoration under occlusal forces.

Retention and resistance are interrelated and often inseparable qualities.

Factors Affecting the Resistance Form

1. *Taper:* Theoretically maximum retention is obtained if a tooth preparation has parallel walls. But parallel preparation is impossible so a taper of 6° between opposing surfaces is considered to be optimal. Retention diminishes considerably as the taper of opposing walls increases from 0° to 10°.
2. *Surface area:* Greater the surface area of a preparation, greater is retention. Preparation on large teeth are more retentive than preparations on small teeth.
3. Occluso-gingival length it is an important factor affecting retention form. For the restoration to succeed, the length must be great enough to interface with the arc of the casting providing about a point on the margin on the opposite side of the restoration. So in shorter walls, the degree of taper should be less.
4. Diameter of the tooth: If the tooth has short walls and small diameter, it successfully resist the tipping forces. This is because the preparation on the smaller tooth will have a short rotational radius for the arc of displacement and the occlusal portion of the access wall will resist displacement.
5. Paths of withdrawal: Retention is improved by geometrically limiting the number of paths along which a restoration can be removed from the tooth preparation. Maximum retention is achieved when there is only one path. A short overtapered preparation will have more than one path of withdrawal and is therefore less retentive.
6. *Type of preparation:* Retention of complete coverage crown is double than partial coverage crown.
7. *Roughness of the surfaces being cemented:* Retention is increased if the restoration is roughened or grooved. Air abrading the fitting surface with 5^0 less of alumina has shown to increase the retention by 64% (0′ Comor 1990). But deliberately roughening the tooth preparation hardly influence retention, and is not recommended.

Materials being cemented: Retention is affected by both the casting alloy and the core or build up material. Therefore, base metal alloys are better retained than less reactive high gold content metals as more reactive the alloy the more is the adhesion there will be with certain luting agents.

Type of luting agent: Adhesive resin cements are most retentive.

Film thickness of the luting agent: There is conflicting evidence about the effect of increased thickness of the cement on retention of a restoration.

Resistance Form

1. *Rounding of axial line angles* tend to reduce areas of stress concentration thus adding in retention form.
2. *Conservation of tooth structure*

Structural Durability

The preparation must be designed so that it will be possible to have an adequate bulk of metal to allow the restoration to withstand the forces of occlusion. There should be 1.5 mm clearance on the functional cusps and 1 mm on the non-functional cusps. Inadequate clearance makes the restoration weaker. In addition, it leads to shallow, flat anatomy on the occlusal surface of the restoration.

1. Functional cusp bevel: A wide bevel on the lingual inclines of the maxillary lingual cusps and the buccal inclines of mandibular buccal cusps provides space for an adequate bulk of metal in an area of heavy occlusal contact. If a bevel is not placed on functional cusps the casting will extremely than in case of heavy stresses over contouring of restoration is done. This will result in definitive occlusal contour.
2. Axial reduction: Inadequate axial reduction will result in thin wall of restoration which will be subjected to distortion. An attempt to compensate this by over contouring the axial surfaces can have disastrous effect on the periodontium

Marginal Integrity

The restoration can survive in the biological environment of the oral cavity only if the margins are closely adapted to the cavo surface finish line of the preparation. The configuration of the preparation finish line dictates the shape and bulk of metal in the margin of the restoration and can affect the fit of the margin.

More acute the angle of margin, smaller the space between the restoration margin and the tooth. Moreover, the acute angle of metal can be easily burnished thus improving its adaptation.

To acute an angle at the margin results in unsupported margin on a wax pattern that lends itself to distortion when the wax pattern is withdrawn from the die and during investing.

Therefore, prepared restoration for metal restoration is Chamfer. This finish line has been shown experimentally to exhibit the least stress. So that the cement underlying it will have less failure. The margin of the cast restoration that fits against it combines an acute edge with a nearby bulk of metal.

The shoulder is the finish line of choice for porcelain jacket crowns. The wide ledge provides resistance to occlusal forces and minimizes stresses that might lead to fracture of the porcelain.

The bevel is a modified form of shoulder finish line. It forms an obtuse angle with the axial wall. It allows for a minimum collar of metal on porcelain fused to metal restoration. It is optimum configuration for the labial finish line of porcelain fused to metal restorations in highly esthetic areas such as on maxillary incisors.

The shoulder with a bevel is used as a finish line. It is utilized for the gingival finish line on the proximal box of inlays and onlay for occlusal shoulder of onlays on mandibulars three quarter crowns. It is used in those situations where a shoulder is already present either because of caries or previous restoration.

BIOLOGICAL CONSIDERATIONS

Pulpal Consideration

a. *Conservation of tooth structure:* The use of partial coverage preparations, when possible is one of the best means of conserving tooth structure and usually causes less pulp damage. In full coverage preparation as much tooth structure as practicable should be retained.
b. *Depth of reduction:* Controlling the amount of tooth reduction is necessary to avoid pulpal damage. It is best provided by placing strategically located depth cuts in unprepared tooth surfaces to the desired depth. The intervening tooth structure is then removed by using the base of depth cut as guide to proper reduction.

In case of deep preparations owing to caries or other reasons, an insulating base material should be placed over the area in proximity to the pulp.

c. *Speed of reduction:* Rapid continuous removal of tooth structure causes rapid heat build up with a greater potential for irreversible pulpitis. So reduction should be performed intermittently.

d. *Instrument age and use of pressure:* Only sharp instruments, should be used for bulk tooth reductions since dull ones create more friction and thus more heat.

Rotary instruments must be held formally against the tooth to permit a controlled removal of tooth structure. However, use of excessive pressure for rapid reduction should be avoided, since this causes undue heat generation.

Use of Coolants

Application of coolant is most beneficial during tooth preparation. Handpiece can deliver a water stream. Water spray or air to the rotary instrument and tooth surface during reduction. A water stream is the most effective means of cooling followed by a water spray and then air.

The disadvantages of water is that it interferes with vision and is therefore not suited for cooling a tooth during refinement, smoothing and the placement of the intricate details required with certain preparation designs.

Periodontal Considerations

A supragingival location for the finish line is preferred whenever possible. This location allows good visual access for evaluating finish line form facilitates an accurate impression of the preparation tooth, allows access for marginal refinement, polishing and more accurate assessment of prosthesis and contour.

These are certain exceptions where finish line has to be carried subgingivally.

1. When caries one present subgingivally
2. When extra length of preparation is required for extraretention
3. For achieving more esthetic result when placing ceramic restorations.

Esthetic Principles

Achieving a color that matching the surrounding which necessitates certain minimal thickness in the ceramic material which can be only be accomplished by adequate and uniform reduction of the facial surface.

Cast Metal Onlay

The cast metal onlay restoration spans the gap between the inlay which is primarily an intracoronal restoration and the full crown which is totally extracoronal restoration.

The cast metal onlay is a restoration which caps all of the cusp of the posterior tooth.

Indications

1. For restoring damaged occlusal surface in a conservative manner.
2. For the restoration of the severely worn dentition when the teeth themselves are minimally damaged.
3. For replacement of an MOD amalgam restoration when sufficient tooth structure remains for retention and resistance form.

Contraindications

1. In cases of extensive caries or existing restoration which are extending well beyond the facial and lingual line angles.
2. When the oral hygiene is poor.

Advantages

1. It is more conservative of tooth structure than the full crown preparation.
2. It is designed to distribute occlusal loads once the tooth in a manner that virtually eliminates future tooth fracture.
3. Its supragingival margins are less irritating to the gingiva.

Disadvantages

1. Unesthetic and cause display of metal.

Cavity Preparation

Initial Cavity Preparation

Convenience form and occlusal reduction: The reduction of the cusps should be the first step are:

a. This improves both the access and visibility for subsequent steps in cavity preparation.
b. Once the cusps an reduced, it is easier to assess the length of the remaining crown which determines the degree of occlusal divergence for adequate resistance form.
   - Using a No. 271 (Fig.14.1) carbide bur parallel to the long axis of the tooth crown, prepare a 2 min depth cut along the central groove.
   - The depth cut should be extended facially and lingually just beyond the caries to sound tooth structure.

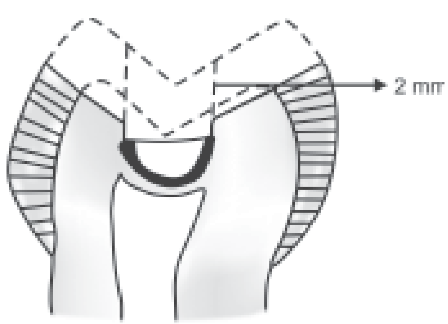


Fig. 14.1: Showing cutting teeth

   - With the side of the No. 271 carbide bur, cut uniform 1.5 mm deep depth grooves on the remaining occlusal surface. The grooves should be placed on the crest of the triangular ridges and in the facial and lingual groove regions.
   - With the depth grooves serving as guideline for the amount of reduction, complete the cusp reduction with the side of the No. 271 bur. The mesial and distal marginal ridges are not reduced at this time.
   - The gingival to occlusal divergence of these cavity walls may range from 2 to 5 degrees from the line of draw. If the walls are short, a minimum of 2 degrees occlusal divergence is desirable and if the walls are of sufficient length then divergence of 5 degrees can be given.

Outline, Retention and Resistance Form:

Occlusal step: After cusp reduction, there should be a 0.5 mm deep occlusal step in the central groove region. Maintaining the pulpal depth of 0.5 mm of the step, extend it facially and lingually just beyond any carious areas to sound tooth structure.

- Extend mesially and distally for enough to expose the proximal dentino-enamel junction.
- The facial and lingual walls of the occlusal step should go around the cusps in graceful curves and isthmic should only be as wide as necessary to be in sound tooth structure.
- Caries deeper than 0.5 mm pulpally should not be removed at this stage.
- The occlusal step approaches the mesial and distal surfaces, it should widen faciolingually in anticipation for the proximal boxing.

Proximal Boxing

Continuing with the No. 271 carbide bur, isolate the distal enamel by cutting a proximal ditch. Slight pressure toward the enamel is necessary to prevent the bur from cutting only dentine.

- The mesiodistal width of the ditch should be 0.8 mm, 0.5 mm at the expense of dentin and one-third at the expense of enamel.
- While penetrating gingivally, extend the proximal ditch facially and lingually beyond the caries to the desired position of the facioaxial and linguoaxial line angles. Ideal extension gingivally of a minimal, cavitated lesion will eliminated caries on the gingival floor as well as provide 0.5 mm clearance of unbeveled gingival margin with the adjacent tooth.
- Proceeding with the No. 271 carbide bur, make two cuts, one at the facial limit of the proximal ditch and the other at the lingual limit. Extend these cuts until the bur is nearly through the marginal ridge enamel. This weakens the enamel which is fractured with a spoon excavator.
- The walls of the proximal walls are planed by hand instruments to remove all undermined enamel chisel and halchets may be used depending upon the access.
- Swallow (0.3 mm) deep retention groove may be cut in the facioapical and linguoaxial line angles with the No. 109 L carbide bur. These groove are in sound dentine but not contacting DEJ. These grooves are indicated when the prepared tooth is short.

Final Cavity Preparation

Removal of Infected Carious Dentin and Application of Basis:

Evaluate the internal walls of the preparation visually and tactilely for any infected carious dentine. If infected carious dentine is present, it is removed after proper isolation use a slowly revolving rank (No. 2 or 4) spoon excavator to remove the carious infected dentine. If the bur is used, then only one spray is used so as to improve visibility and intermittent cutting at stall out speed is done.

- If the excavaled region is shallow or moderately deep, then light cured GIC is applied as a base.
- If the lesion closely approaches the pulp, rubber dam should be applied before removal of infected dentine. Then apply a lining of calcium hydroxide except at the peripheries. Over this give a base of light cured GIC: But as little dentine is available for bonding, suitable undercuts or cover are cut with No. ¼ carbide bur.

Remaining old restorative material if indicated to be removed. After excavation of caries and old restorative material ensure at least three flat starts at normal depth.

After GIC has set apply petroleum Jelly over it.

Preparation of Bevels and Flares

After the cement base is completed, the slender, flame shaped, fine grit diamond instrument is used to bevel the occlusal and gingival margins and to give secondary flare on the distalingual and distofacial walls. Counter bevels are given on the reduced cusps.

For this gingival retraction cord is applied and bevels are given which results in 30-40 degree marginal metal (Fig. 14.2).

The counter bevel should be wide enough so that cover surface margin and beyond any contact with the opposing dentition.

After beveling and flaring, slightly round any sharp junctions between the counter bevels and the secondary flares.

Fig. 14.2: 30°-40° Marginal bevel

For additional retention form: For this skirts, collor or slots can be used.

Skirt preparation (Fig 14.3): Skirts are thin extensions of the facial or lingual proximal margins of the cast metal onlay that extend from the secondary flare to a termination just pass the transitional line angle of the tooth.

These are prepared entirely in enamel. The addition of properly prepared skirts to three of four line angles of the tooth virtually eliminates the chances of post restorative fracture of the tooth as it braces the tooth and is primarily an extracoronal restoration.

The disadvantage is that it increases the display of metal.

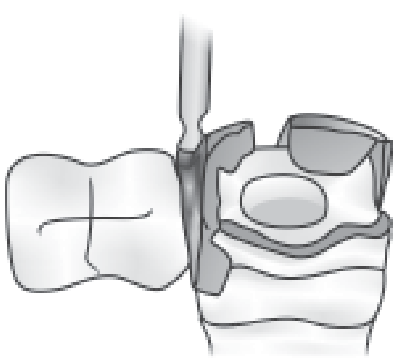


Fig. 14.3: Skirt preparation

Fig. 14.4: Collar preparation

Collar preparation (Fig. 14.4): To increase the retention and resistance forms when preparing a weakened tooth for MOD onlay capping all cusps, a facial lingual color or both may be provide.

For this 271 carbide bur at high speed is used parallel to line of draw to prepare 0.8 mm deep shoulder around lingual or facial surface to provide for a collar 2 to 3 mm high occlusogingivally. The gingival margin of the shoulder should be tightly beveled.

Slot preparation: Occasional the use of a slot in the dentin is helpful to provide the necessary retention form in case of MO onlay on the mandibular 2nd without any distal tooth. So a slot is given instead of box as it is more conserving of tooth structure and linear extent of marginal outline is less.

To form this slot, use a No. 169 L carbide bur whose long axis should parallel the line of draw. A slot is cut in dentin so that it would pass midway between pulp and DEJ. Mesiodistally the width is same as width of bur, faciolingually 2 mm and gingivally 2 mm deep.

2. *Complete cast metal crown preparation:* Complete cast crown preparation is a restoration that covers all coronal tooth surface.

Indicators

1. Presence of extensive caries
2. Existing large deflective restorations

3. Fracture of the tooth
4. Need to change contour, as for removable partial dentive retention. Case the tooth is to be used as abutment
5. Abutment tooth short occlusocervically
6. Long edentulous span
7. Greater than average occlusal forces
8. In endodontically treated teeth

Contraindications

When the treatment objective can be needed with a more conservative restoration.

Advantages

1. It completely encircles the coronal portion of the tooth, so this complete cast crown affords the most effective retention and resistance form of all of the extracoronal restorations.
2. This characteristic allows it to be used in situation in which tooth form and alignment are not ideal and when a less than perfect preparation is a likely result.
3. It can be used to make relatively extensive alternations in tooth form and occlusion.

Disadvantages

1. Lack of esthetic qualities
2. Tooth preparation is extensive causing more pulpal and periodontal damage

Preparation

The clinical procedure to prepare a tooth for a complete cast crown consists of the following steps.

1. Determine a suitable finish line before tooth preparation.
2. Occlusal depth cuts: These are helpful for teeth in critical arch position with a reduced interocclusal clearance.

These are placed using the tapered round end diamond instrument with the instrument being held parallel to existing occlusal grooves whenever possible and following the anatomic contour of the occlusal surface. The depth groves are placed approximately 1 mm deep. These are placed in the buccal and lingual developmental grooves and in each triangular ridge extending from the cusp tip to the center of the base.

As the centric or functional cusp is to be protected by an adequate thickness of metal to a functional cusp bevel has to be given to ensure this. For this the depth of guiding groove should be less than 1.5 mm in area of centric slop and it should gradually diminish in a cervical direction.

On the non-functional cusp, the groove should be parallel and in the intended cuspal inclination and on the functional cusp, it should be angled slightly flatter to ensure the additional reduction of the functional cusp.

- *Occlusal reduction:* Once the guiding grooves have been deemed satisfactory, the tooth structure that remains between the grooves is removed with the carbide or the narrow, round and tapered diamond.

  The occlusal reduction is completed in two steps half the occlusal surface is reduced first so that the other half can be maintained as a reference. Once the reduction of first half has been completed reduction of remaining half can be completed.

  On completion, check that a minimum clearance of 1.5 mm has been established on functional cusps and at least 1.0 mm on non-functional cusps.
- *Initial proximal surface reduction:* It is performed to break contact with the adjacent tooth only, so as not to establish a proximal finish line.

The thin tapering diamond is positioned parallel with long aims to provide 2 to 5 degrees convergence on the mesial surface. The tooth adjacent to the tooth being prepared is to be protected during preparation. Excessive proximal contours are routinely modified with enameloplasty to permit seating of the casting.

The distal surface is also prepared in the same manner.

Do not create the gingival finish line at this time.

- *Facial and lingual reduction:* The facial and lingual reduction is carried out in two plane.
  - The depth cuts should follow the existing contour of the tooth to produce two distinctly different angulation to the occlusal and cervical aspects of each depth cuts.
  - Generally, two or three depth cuts, equally spaced along the mesiodistal dimension of the facial and lingual surfaces provide adequate reduction guides.

The depth cuts are placed 0.7 to 1.0 mm deep in the occlusal aspect of the tooth and decrease slightly in depth cervically to terminate in a chamfer 0.3 to 0.5 mm in depth.

The cervical portion of depth cut is accomplished first with diamond held parallel to the long axis of tooth. The occlusal portion of depth cut is accomplished with diamond paralleling the existing contour.

The tooth structure located between the depth cuts is removed using the same instrument and reduction extended to form the reduced proximal surface.

First proximal reduction: Now establish the finish line on the proximal surfaces preferably supragingivally by reducing the cervical third of proximal surface.

Care should be taken to maintain 2 to 5^0 convergence.

Finishing of the Preparation

A smooth sharp angles and irregular surface with the same size diamond but with a finer grit.

The finish lines should be refined so that it has uniform depth and is devoid of rough areas.

Preparation for Metal Ceramic Crown (Fig. 14.5)

Metal ceramic crown consists of a complete coverage cast metal crown that is veneered with a layer of fused porcelain to mimic the appearance of a natural tooth.

Indications

1. Indicated on teeth that require complete coverage, where significant esthetic demands are placed on the dentist.
2. Retainer for fixed partial dentine because its metal substructure can accommodate cast or soldered connectors.
3. Retainers for RPD's.
4. Patients with a reduced interocclusal clearance or a strong masticatory musculative.

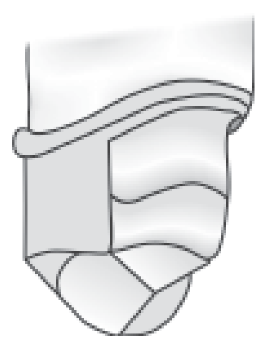


Fig. 14.5: Posterior metal ceramic tooth preparation

5. Endodontically treated teeth.
6. Other indications similar to cast metal crowns.

Contraindications

1. Patients with acute caries or untreated periodontal disease.
2. In young patients with large pulp chambers due to high risk of pulp exposure.
3. When more conservative restorations are feasible.

Advantages

1. The metal ceramic restoration combines to a large degree, the strength of cast metal with the esthetics of an all ceramic crown. The underlying principle is to reinforce a brittle. More cosmetically pleasing material through support derived from the stronger metal substrucure.
2. As all axial walls are included, retentive qualities are excellent.

Disadvantages

1. The porcelain fused to metal veneers are susceptible to fracture due to its brittle nature.
2. Facial reduction and margins for porcelain veneer crowns subject the pulp and investing tissues to trauma.
3. Difficulty in shade matching.
4. Laboratory lost high.
5. Technique sensitive.

Preparations

Incisal reduction: The incisal plane is reduced from 1.5 to 2.5 mm so that there is suitable thickness of metal and porcelain. Incisal reduction should be adequate to ensure clearance in protrusive movements of the mandible, encourage esthetics and enhance function.

Depth cuts at a depth of 1.5 mm are given parallel to the terminal protrusive functional pathway. These are normally placed one each and at junctions of each proximal.

The occlusal reduction for posterior metal ceramic crown is similar to that of complete metal crown except the occlusal reduction is a minimum of 2 mm over the surface veneered with porcelain.

Step 1 – Focial Reduction

Depth cuts identifying the path of draw at the height of contour are placed. The depth is 1.5 mm and are three in number. In the incisal half, these depth cuts generally follow the original contour of the facial surface.

After placement of the depth grooves, the risks of unprepared tooth structure between the depth cuts are removed. This reduction is continued around the line angles to establish the profile of the proximal reduction. The gingival extent of this reduction results in a uniform ledge that maintains a suitable axial depth.

The facial reduction closely follows the original facial tooth contours.

Step 2 – Proximal Reduction

It is accomplished to maintain parallelism with the line of draw without damaging an adjacent tooth.

To prepare the proximal surface, align the instrument used for facial reduction over the profile of the proximal reduction and with the orientation parallel to the line of draw, position the tip to create a gingival, ledge the same dimensions as the facial, check to ensure that the instrument passes through without damaging the adjacent tooth. The proximal reduction is carried out with the same orientation and creating a taper of 6.

Step 3– Lingual Reduction

Anatomically, the lingual surface of the anterior tooth has two distinct components. The angular and the lingual fossa. Accordingly, preparation of this surface is also divided into two component stages.

Angular Wall Reduction

The angular axial wall is the only portion of the lingual surface to provide parallelism with the axis of draw. Depending on anatomy of the tooth and position of the gingival tissue, it may be possible to produce a short axial wall that is relatively parallel to the axis of draw.

This reduction is accomplished with a tapering diamond but of lesser diameter as compared to that used for labial reduction.

Lingual fossa reduction: The reduction of the lingual fossa depends on the design of the restoration. If the lingual surface of the restoration is metal, the reduction is of only 1 mm. However, if the design is full porcelain coverage reduction must be 1.25 mm to 1.5 mm.

Depth cuts are made with tip of tapering diamonds and the final reduction of the lingual fossa is accomplished with a wheel-shaped or football shaped diamond instrument.

Gingival Margin Preparations

Three types of facial finish lines have been used on metal ceramic preparations. Heavy chamfer, shoulder and beveled shoulder.

Heavy chamfer is the easiest to form, but the metal framework is thinner cervically and undergoes more distortion during the healing and cooling cycles as porcelain is fused to metal.

Also overall porcelain thickness decreases as margin is approached: As adverse effect on esthetics.

Both the shoulder of the beveled shoulder finish line are harder to form but permit the metal framework to be more resistant to distortion during firing cycles.

Good cervical porcelain colour is easier to obtain with this finish line without overcontouring of the restoration.

The shoulder should be made with falt end tapering diamond and should be carried pass the proximal contact point where it gradually merges with lingual chamfer line.

Posterior Metal Ceramic Tooth Preparation (see Fig. 14.5)

Reduction for posterior crown with facial
- Ceramic Veneer
- Facial shoulder – 1 mm
- Facial reduction – 1.5 mm.
- Lingual and proximal chamfer 0.3 to 0.5
- Occlusal reduction – 1.5 mm.

Reduction for full porcelain coverage
- Facial reduction – 1.5 mm
- Facial shoulder – 1 mm
- Lingual and proximal reduction with heavy chamfer 0.8 mm
- Occlusal reduction – 2-2.5 mm.

Partial Veneer Crown

A partial veneer crown is a restoration covering two or more surfaces of a tooth. The surfaces usually covered are the lingual, proximal, occlu sal or incisal.

Indication

1. Intact or minimally restored with
2. Teeth with average or above average crown length

3. Teeth with normal anatomic crown form i.e. without excessive cervical construction.
4. Anterior teeth with adequate labiolingual thickness.

Contraindications

1. High caries rate: Unveneered surface and margin finish line interface are susceptible to decay.
2. Teeth with extensive core restorations.
3. Deep cervical abrasion: It is difficult to establish a finish line.
4. Short teeth: Because of inadequate resistance and retention.
5. Bell shaped teeth: Teeth severly constructed at the cervical require more axial reduction and provide adequate groove length. This can flopardize pulpal health.
6. Thin teeth: Preparation of groove may undermine enamel.

Advantages

1. Tooth reduction is conservative
2. Natural appearance
3. Increased biocompatibility with intracrevicula space.
4. Margin accessibility for finishing and cleaning is unproved.
5. Complete seating of casting is more easily verified with at least one margin visible.
6. Complete seating of the casting during cementation enhanced by diminished hydrantic pressure.
7. Electric pulp testing can be accomplished on the intact enamel surface.

Disadvantages

1. Not as retentive as complete crown
2. Limited display of metal with partial veneer crown
3. Skillful preparation is critical to avoid metal display
4. Limited to fairly intact teeth with average length clinical crowns

Three Quarter Crown Preparation (For anteriors) (Fig. 14.6)

This crown involves three of the four axial surfaces of the tooth

Preparation (Cuspid)

1. Incisal reduction: Using a tapered round and diamond, reduce the incisal edge 1 mm at 454 degree angle to the long arcs of the tooth.
2. Lingual reduction: Using a football shaped diamond, reduce the lingual surface in two planes bearing a slight ridge running incisogingivally along the centric of the lingual surface.

   Clearance with the opposing tooth is 0.7-1 mm.

   Lingual gingival reduction: Using a tapered round ended diamond make a chamfer 0.5 mm deep at the cervical finish line. The reduction parallels the long arcs of the preparation extend the chamfer to include lingual line angles.
3. Interproximal reduction:
   a. Using a 169 L carbide bur, reduce the proximal surface by moving the bur

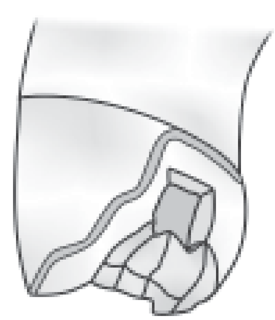


Fig. 14.6: Quarter crown preparation

from the lingual to the facial surface – Position the bur so that the tip of the bur is further facial than the shank. Do not break contact with the adjacent teeth at this time.

b. Using a narrow chamfer diamond, establish a light chamfer finish line on the proximal surface blending it with the lingual chamfer.
c. Using a hatchet instrument from the facial surface the contact with the adjacent teeth is broken to establish labioproximal extensions.

4. Proximal grooves: Using a 169 L carbide bur place the proximal grooves parallel to the mesial two thirds of the facial surface. These are designed to create a definite lingual wall that resists lingual displacement, the facial wall of the groove should be continuous with the proximal flow. These are minimum 3 mm long at terminate 0.5 mm short of finish line.
5. Incisal groove: Using a 37 inverted cone carbide bur, develop a 0.5 to 1 mm groove connecting the proximal grooves. The groove should be in dentin and parallel to the DEJ. The groove is not placed at the expense of incisal edge.

Facial Bevel

Using a fine, flame shaped diamond bur, develop a narrow bur 0.5 mm on labiomesially finish line at Rt L's to incisal two third.

Finishing the prepartion: Using a fine gent diamond round all the line angles.

Posterior partial veneer crown:

It is similar to that for anterior partial veneer crown.

2. *Seven-eight crowns (Fig. 14.7):* These are the extensions of the three quarter crown to include a major portion of the facial surface, i.e. mostly the distal surface.

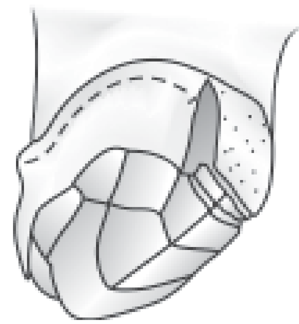


Fig. 14.7: Seven-eight crown preparation

The mesial half of the buccal tooth surface remains intact and is protected by a narrow contrabevel or chamfer similar to the one used in the three quarter crown preparation.

A groove in the middle of the buccal surface is placed parallel to the path of withdrawal. Distal to this groove, the buccal surface is reduced in two planes, cervical and occlusal with the cervical paralleling the path of withdrawal and the occlusal following the normal anatomic contour. The lingual surface of the tooth also is reduced in two planes and functional cusp bevels are incorporated.

Occlusal Reduction

1. Place depth grooves in the central and developmental grooves as well as on the crests of the triangular ridges. To deliminate the extent of the lingual centric cusp bevel, they should extend onto the lingual surface of the tooth.
2. Remove the tooth structure between the depth grooves. Concave shaping of the resulting mesio buccal incline will permit the occluso-cervical height of the cusp to be maintained.

Facial Reduction

1. Place three alignment grooves in the lingual wall and fourth in distobuccal line angle.
2. Start the reduction in the middle of the lingual surface. The mesial half is prepared like a three quarter crown and the distal half like a complete crown.
3. Carry the facial reduction efficiently mesial to include the buccal groove.
4. Some additional reduction is done on the occlusal half of the buccal surface. This will allow for contouring of the restoration, so that when viewed from the mesial, the distal half is hidden behind the mesiobuccal cusp.

Groove Placement, Flaring and Contrabevel

1. Prepare the mesial groove like the three quarter crown.
2. Place the buccal groove parallel to the mesial groove. It is not necessary to flare buccal groove is the flat surface of maxillary molar precludes any insupported enamel when the groove is placed.
3. Connect the grooves with a smooth contrabevel that follows the ridge of the mesio buccal cusp.
4. Finishing of all surfaces of preparation.

Fabrication of Wax Pattern

After the reduction, impressions are made with elastomeric impression materials and waking casts and dies are made.

Forming the Pattern Base

Fabricate the die and incrementally add liquid wax from a No. 7 wax spalular by the flow and press method form the proximal facial – lingual surface aspects of the pattern. Wax shrinks as it cools and harden and therefore tends to pull away from the die. This effect can be minimized and pattern adaptation thus improved by applying finger pressure for at least several seconds on each increment of wax soon after surface solidification and before any subsequent wax additions. In this incremental technique, the wax that is flowed or the previously applied wax must be hot enough or else voids will be formed.

Forming the Proximal Contour and Contact

The normal proximal contact relationship between teeth is that of two curved surfaces lowering one another. Therefore, the contact on each curved is a point inside a small area of near approach. However, soon after eruption wax of contact point occurs to create a contact surface.

It is important that contact be of proper form and in right position. So the diameter of proximal contact faciolingually and occluso-gingivally are measured. One should try to reproduce the contact which is neither broad occlusogingivally nor buccolingually. It should not be positioned too far gingivally or occlusally.

Forming the occlusal surface: The fundamental principles in the following method of waking were developed by Paijne. The technique is particularly applicable when capping cusps.

To obtain the faciolingual position of the cusp lips, divide the faciolingual width of the tooth in quarters. Facial cusps are located on the first facial quarter line. Lingual cusps will fall on the first lingual quarter line. To obtain the mesiodistal position of the cusp tips, note the regions in the opposing tooth that should receive the cusp tips. Now wax to the patterns small cones of inlay wax to establish the cusp lips one at a time.

Now wax the inner and outer aspects of each cusp being careful not to generate premature occlusal contacts. Onlay one aspect of each cusp should be waxed into occlusion at a line.

First wax mesial slopes of the cusps (one at a time) proximal marginal ridge areasand then wax distal slopes of the cusps (one at a time).

After the cusps are formed, wax in the proximal marginal ridge areas. Develop the same bevel to adjacent proximal marginal ridges even though occasionally this may sacrifice a contact on are of the two ridges. This avoids a 'food trap' that otherwise would be created. The mesial and distal pit regions should always be carved out enough to have them on a lower level than the respective marginal ridges.

To complete the occlusal wax up, add wax to the fossa until they contact the opposing centric holding cusps. Establish spill ways for the movement of food by carving appropriately placed grooves. Flat plane occlusal relationships are not derived.

This method helps to develop a pattern with minimal stress and distortion and prevents large shrinkage.

Interocclusal Records

The occlusal surface can also be weakest when using FCP core IP core or IP interocclusal record as a reference.

These records provide information regarding the opposing teeth in maximum intercuspal position and FCP core also provides the information about the pathways of opposing cusps during mandibular movements.

Finishing the Wax Pattern

There must be a continuous adaptation of wax to the margins with no voids, fold or foultls. If adaptation to questionable, result the marginal wax to a distance into the pattern of approximately 2 mm. Apply finger pressure immediately after surface solidification and before subsequent cooling of the wax maintaining this pressure for at least is seconds. Additional wax should be added during the remelling procedure to ensure a slight excess of contour and extension beyond the margin.

Now slightly overwax the proximal contact so that the wax die will fail to seat on the cast by a slight amount. This provides a small excess of metal in the casting for polishing the contact.

The surfaces should once again be smooth. The grooves are smoothed by rubbing with cotton that has been twisted onto a round tooth pick.

Initially Withdrawing and Residing the Pattern

Care must be exercised when doing this as this may lead to distortion of one portion will be lodged in position while the other is moving away from its position.

To avoid this U-shape wires with a hook is attached to the pattern with operative pliers, lightly grasp the U-shaped wire by its loop nad carefully endevour to attain uniform traction and movement of the entire pattern while lifting it from the preparation.

Then resert it, once satisfied, remove the U-shaped with and correct the holes lift after its removal.

15 Isolation of the Operating Field

THE ADVANTAGES OF ISOLATING THE OPERATING FIELD

1. Aids in maintaining dry clean operating field.
2. Improves access and visibility.
3. Improves the manipulation of dental materials.
4. Helps in protecting the adjacent hard and soft tissues.
5. Improves the operating efficiency.

The oral cavity is a complex environment which can present obstacle to physical diagnosis and mechanical treatment of dental and oral tissues. Therefore, the oral environment is to be properly controlled to prevent them from interfering with any operative procedures.

The operating field can be magnified by:

1. Proper patient position (physiological position, i.e. to facilitate and manipulation is easy)
2. Rubber dam by isolation
3. Fluid and debris evacuations by sucking instruments and equipment.
4. Tissue retraction by approached retractor.
5. Use of mouth props to stabilized the operating field.
6. Use of pre-medicamention for better co-operation for patient.

RUBBER DAM ISOLATION

Rubber dam was introduced into dentistry by *Dr. S. C. Barmum in 1864,* and is one of the most effective methods for isolation the operating field.

Uses of Rubber Dam

1. It defines the operating field by scluding one or more teeth from the oral environment.
2. It eliminates saliva from the operating site.
3. It retracts the soft tissue, thereby improves access and also provide protection to soft tissues.
4. Using rubber dam during excavation of deep carious lesion can prevent or minimize pulpal contamination with oral fluids if pulpal exposure occurs.
5. Prevents aspiration or swallowing of restorative material, flaked tooth structure and even small instruments while the procedure is carried out.
6. By all this, it remarkably aids in patient comfort and improves operative efficiency.

Definite Advantages of Rubber Dam in Operative Dentistry

1. The operator can obtain appropriate dryness of the operating field so

procedures like caries removal, proper cavity preparation and insertion of restorative material can be best performed.
2. It retracts the cheeks, lips and tongue thereby provide better access and visibility of the operating site.

   The gingival tissue is also slightly retracted enabling the operator to have better access and visibility to gingival aspect of the cavity and restoration.
3. The dark non-reflecting surface provides a contrasting background for the operating field thereby better access and visibility.
4. The rubber dam prevents moisture contamination of the restorative material during insertion, thus improving or maintaining the physical properties.
5. It prevents swallowing or aspiration of small instruments, debris, or restorative material associated with operative procedure.
6. The rubber dam protects soft tissue from rotating burs and stones.
7. It also protects the soft tissue from irritating or distasteful medicaments like itching agents or certain cements.
8. It acts as a barrier against infectious agents present in the patient's mouth thereby protecting the operator.
9. It eliminates the time consumed in rinsing and expectoration by the patient thereby improves productivity.
10. It discourages excessive patient conversation during the procedure thereby improves operating efficiency and productivity.
11. The rubber dam retainers aids in providing moderate extend of mouth opening during the procedure.
12. Rubber dam facilitates '*Quadrant restorative procedures*'.

Disadvantages of Rubber Dam

1. Rubber dam cannot be applied to teeth that are not sufficiently erupted to receive a retainer.
2. They cannot be used in extremely malpositioned teeth.
3. They cannot be used in asthmatic patients who have difficulty in breathing through nose.
4. Rubber dam should not be used in patients who cannot tolerate it because of psychological reason.
5. Rubber dam cannot be applied on tooth with weak periodontal support as its application can aggravate the inflammation.
6. It cannot be used in patients who are allergic to latex.
7. Inappropriate retainer can impinge on the soft tissues and traumatize it.
8. Saliva can accumulate beneath the rubber dam, when it is used for longer duration.
9. There are possibilities of swallowing or aspiration of the clamp it loosens accidentally.

Armamentarium for Rubber Dam Isolation

- Rubber dam material.
- Rubber dam retainer (clamp).
- Rubber dam holder.
- Rubber dam punch.
- Rubber dam clamp forceps.
- Rubber dam napkin.
- Lubricant like cocoa butter or petroleum jelly.
- Plastic template or rubber stamp.
- Dental floss
- Occasionally modelling compound to secure clamp.

Rubber Dam Material

- It is available in sheets of 5 × 5 inch or 6 × 6 inch. It can be:
- Thin (0.15 mm)
- Medium (0.2 mm)
- Heavy (0.25 mm)
- Extra heavy (0.30 mm)
- Special heavy (0.35). The thicker dam material it to be used when tissue retraction is needed. It is also resistant to tear, so can be used in areas where tight contact is present.

The dam material has a shiny surface and dull surface. The dull surface is always placed towards the occlusal surface as it is less light reflective.

The dam material comes in both dark and light colors. The dark color is preferred as it is in contrast to the operating structures.

RUBBER DAM RETAINER (CLAMP) (Fig. 15.1)

The retainer anchors the rubber dam material to the tooth which is posterior most to the isolated site.

The retainer can be winged or wingless. The winged retainer has both anterior and lateral wings. These wings provide extra retraction of the rubber dam from the operating field and also allows attaching the dam to the retainer before the dam with retainer is conveyed to anchor tooth.

The clamps come in different sizes and shapes, each one is designed for certain teeth. A properly selected retainer will contact the tooth surface areas which prevents locking or tilting of the clamp.

In some clamps the pronges of the retainer are gingivally directed which facilitates placement in partially erupted teeth.

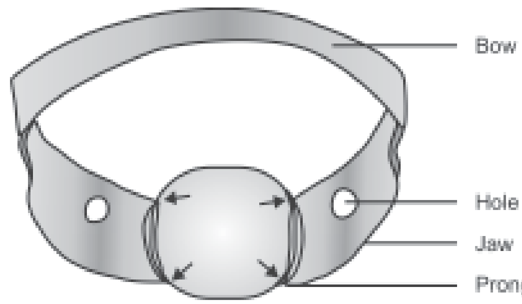


Fig. 15.1: Rubber dam retainer

The main disadvantage of winged retainer is interference with placement of matrix bands, and wedges. The retainer should be tied with a dental floss before carrying it into mouth. This allows retrieval of the retainer or its broken parts if accidentally swallowed or aspirated.

RUBBER DAM HOLDER (Fig. 15.2)

The main objective of rubber dam holder is to keep the periphery of the dam out of the mouth and stretch the dam in all directions. It also helps in retracting the cheeks, tongue, lips, and clears the operating site.

It can be:

1. **Strap type:** Which derives anchorage from patients back and is attached to the corner of the dam. E.g. *wood bury holder, and Wizard holder.*
2. **Hanging Frame:** Holders which the U shaped elliptical or rectangular metal or plastic frames with multiple prongs at the periphery which engage the dam material. They are easy to apply and allow only minimal contact of the dam material with skin. Their disadvantages is there may be in the access for the field of operation. Eg: *Young holder:*

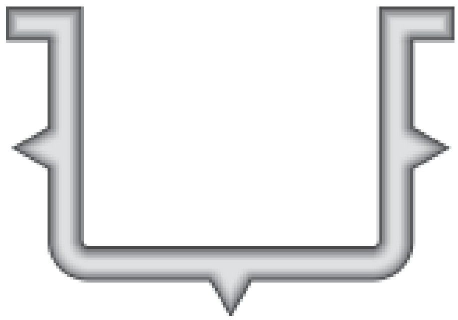


Fig. 15.2: Rubber dam frame

Rubber Dam Punch (Fig. 15.3)

It is a precision instrument having a rotating metal disk with six holes of varying sizes and a tapered sharp pointed plunger. It is used to cut the appropriate sized holes in the rubber dam material. The appropriate hole in the table corresponding to the size of the tooth to be isolated is moved to coincide with the plunger.

Place the rubber in between the table and plunger and hole is punched. The larger hold accommodates the molars, medium sized holes for premolars upper canines and incisors while the smallest hole for the lower incisors.

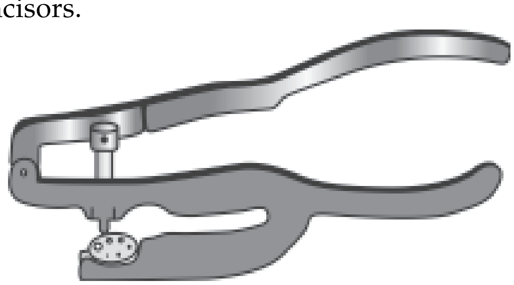


Fig. 15.3: Rubber dam punch

Rubber Dam Clamp Forceps (Fig. 15.4)

This is used to place the retainer on the tooth and also for removal. This forceps retracts the jaws of the clamps when activated by engaging in the holes.

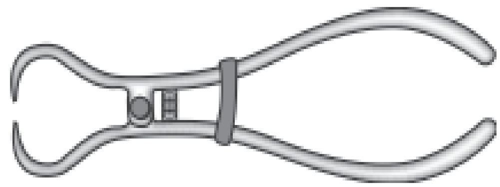


Fig. 15.4: Rubber dam clamp forceps

Rubber Dam Napkin (Fig. 15.5)

These are absorbent paper or cloth towel that is applied between the rubber and the patient's face or tissue to absorb oral fluids in the floor of mouth and perspiration fluids from the skin.

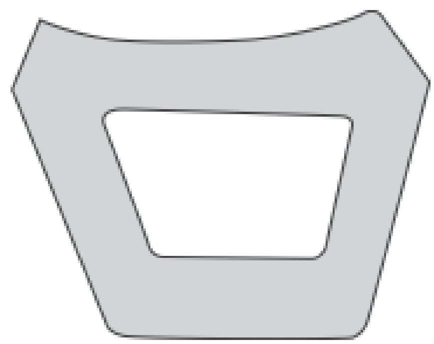


Fig. 15.5: Rubber dam napkin

Advantages of Using Napkins

1. Prevents skin contact with rubber, thereby, reducing the possibility of allergy in sensitive patients.
2. Absorbs saliva at the corners of the mouth.
3. Acts as a cushion and reduces friction of the dam against patient's mucosa or skin.
4. A convenient method of wiping the patients lip on removal of the dam.

Lubricant

This is applied to the area of punched holes to facilitate passing of the dam through the proximal contact.

It can also be used to prevent irritation at the corners of the mouth.

GUIDELINES FOR PLACEMENT OF RUBBER DAM

1. A identification hole can be punched in the upper left corner of the dam for ease of location of that corner on application.
2. When operating on the incisors and mesial surface of canine, isolate from first premolar to first premolar on the other side. In such isolations metal retainers are not required.
3. When operating on the canine, isolate from first molar to the opposite lateral incisors as the anterior teeth can act as finger rests and it also provides better visibility.
4. Always isolate a minimum of three teeth except for root canal therapy in which only the tooth to be treated is isolated.
5. The distance between holes should be equal to the distance between two teeth at its center to avoid wrinkling between the teeth.
6. While punching holes for maxillary teeth punch the hole for central incisor one inch from the superior border of the dam to provide sufficient material to cover the upper lip.
7. While punching hole for the mandibular teeth the first hole to be punched is the hole of the tooth that receives the retainer.
8. When a cervical retainer is to be used (Class V lesions) use a heavier rubber dam material for better tissue retraction and the hole must be punched facial to the arch form.
9. When thinner dam is used the holes should be relatiely smaller as it has better elasticity to achieve adequate seal around the teeth.
10. Usage of rubber dam stamp/template to guide in placement of holes.

PREPARING THE MOUTH FOR RUBBER DAM APPLICATION

All deposits on the involved tooth should be removed to avoid tearing of the dam during its insertion. It also prevents forcing the deposits into the periodontium. Check contact areas with dental tape to evaluate their tightness and presence of any sharp areas. Anesthetize the area before dam application. Vulnerable and previously irritated soft tissue is covered with petroleum jelly before dam application.

PLACEMENT OF RUBBER DAM

1. Lubricate both sides of the rubber dam at the hole area.
2. Select the appropriate retainer and secure it with dental floss. Then carry the retainer to the mouth with the help of rubber dam forceps and try it on the tooth to evaluate stability.
3. Stretch the hole of the dam over the retainer with forefingers. The lip of the hole made to pass completely under the jaws of the clamp.
4. Take the selected dam material and the napkin to position it on the patients face.
5. Now unfold the punched dam and attach it to the prongs on the rubber dam holder.
6. Pass the dam over the anterior anchor tooth and then proceed for placing the dam posteriorly. If needed use a waxed dental floss to assist in passing the dam through the contacts.Insert the dam into the lingual sulcus for complete seal around the tooth using an explorer.
7. Check the placed dam for access and visibility of the operating field. If needed place interproximal wedges for better isolation.

ALTERNATIVE METHODS

First apply the posterior retainer to verify the fit. Remove the stable retainers and hold in forceps and pass the bow through the punched hole from the under side of the dam. Then the retainer with the dam is carried to the mouth and positioned over the anterior tooth. Then apply the holder and insert the dam into the gingival sulcus.

REMOVAL OF A RUBBER DAM

Before removing the rubber dam rinse and suck away any debris that has collected.

Facially, for visibility of each septum of dam, it is stretched it is then clipped with a blunt end scissors, thus freeing the interproximal spaces.

Engage the retainer with forceps and release it to facilitate the removal of dam and frame simultaneously, remove it from the anterior anchor tooth initially.

Wipe the patients lips with napkins immediately on removal. Rinse the mouth and evacuate the water. Gently massage the tissues around the anchor tooth to improve circulation.

SHORT COMING IN APPLICATION AND REMOVAL OF RUBBER DAM

1. Improper hole placement and off center arch form as well as size of the hole.
2. Wrong positioning of the rubber dam frame.
3. Inadequate distance between the holes.
4. Inappropriate retainer.
5. Impingement of soft tissue by clamps.
6. Shredding or tearing of dam during placement.
7. Risk of cutting soft tissue while clipping the septal rubber.

HIGH VOLUME OR SUCKATION APPARATUS

Water and debris accumulated in the mouth during operative procedures employing high speed handpiece can be suctioned by high volume evacuation as it can remove water rapidly and can suck out solid debris.

During above procedure the access and visibility is markedly improved avoiding interruption of the procedure.

The suction tips should be placed as near to the tooth being prepared but should avoid the handpiece head.

Typically it should have plastic or metallic guards to prevent the cheeks, tongue or lip being drawn towards the vacuum stream.

Do not use the evacuator when cutting is not done as it can dehydrate the involved and adjacent tissues.

SALIVA EJECTORS (Fig. 15.6)

This removes the saliva that collects on the floor of the mouth. It can be used along with sponges or cotton rolls.

It can be either metallic or plastic type. The metallic type can be autoclaved. While the plastic type is disposable.

The tip of the ejector should be smooth and should be made of no irritating material. The plastic ones can be moulded to the correct position.

The tip should not suck the soft tissues when they are placed in the oral cavity. Thus, avoiding trauma to lips and cheeks.

If used in conjugation with rubber dam it is preferable to make a hole in the dam to allow the passage of the suction tip through the rubber.

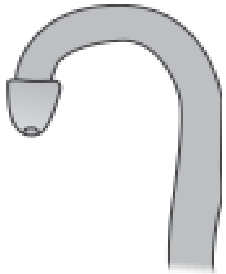


Fig. 15.6: Saliva ejectors

COTTON ROLL ISOLATION

The cotton rolls isolating should be either plain or woven surfaced to improve the compactness. Different sized rolls are placed and stabilized sublingually over or laterally over the salivary gland orifice in the floor of the mouth, under the tongue and in the upper buccal vestibule. But they often need supplementation with other sucking device. They should be replaced when filled with saliva.

Also gauze can be used in the place of cotton rolls. They are less adherent to tissues and hence more effective.

ABSORBANT PAPER PADS/CELLULOSE WAFERS

These are supplied in different shapes to fit different locations. They are more absorbent then cotton rolls/gauze and are well tolerated by tissues.

They are to be used for short periods of isolation.

They further provide certain amount of cheek retraction while remaining moist to prevent inadvertent removal of epithelium.

TISSUE RETRACTION AND PROTECTION MATERIALS

Tongue guards create a wall between the tongue and the operating field. They are usually metallic or plastic tongue depressioners which prevent elevation of tongue during the operative procedure as well as cheek retractor. These are usually disposable type.

MOUTH GAGS

They are rigid rubbery device which facilitate in keeping the mouth open during operative procedures. This is particular useful in patient who have difficult retaining the mouth open position. indicated in patients who have difficulty in doing so.

Which gag half of the upper and lower lips and also pull the lips and cheeks backwards and downwards exposing the facial surface of teeth. They also utilized for photographic purposes.

They are placed between the upper and teeth in the non-operating side with the narrow end directed proximally. To increase the jaw opening the gag is pushed further back or utilize the bigger Gags.

THROAT SHIELDS

They are indicated when small instruments are used in operative fields or when indirect restorations are carried out. A gauze sponge is unfolded and spread over the tongue and posterior part of the mouth. This helps in recovering the instrument or restoration if it is accidentally swallow.

USE OF MEDICAMENTS TO CONTROL OPERATIVE FIELD

1. Antisialogogues such as atropine 5 mg ½ hour before the procedure to decrease salivary flow.
2. Antianxiety drugs like valium 5-10 mg or barbiturates, is given half hour before the appointment.
3. Muscle relaxants.
4. Medication used to controle the gingiva.
5. Pain control medication.

16 General Principles of Instrumentation

POSITIONING OF THE PATIENT IN DENTAL CHAIR

- Proper position of the hand and back rest avoids discomfort to the patient.
- the head should be in a straight line with the patient's back without straining the neck.

a. *Operating on the Mandible*
   - The chair in a upright position.
   - Head rest arranged so that occlusal plane of the mandibular teeth is parallel to the floor, when mouth is open.
   - Enables maximum visibility and accessibility.

b. *Operating on the Maxilla*
   - Chair is tilted backwards.
   - The head rest is placed so that the maxilla is tilted upwords.
   - And should be at 45° to the floor.

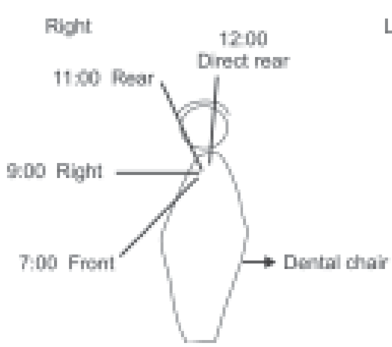


Fig. 16.1: Positioning of the operator in dental chair

Position of Operator (Fig. 16.1)

1. Front position - 7 o'clock position the operator stands in front.
   - Slightly to the side of patient with the patient head turned slightly in direction of the operator.

Indication

1. Facial surface of maxillary teeth.
2. Right posterior teeth.
3. All mandibular areas.

   Side position: 9 o'clock position.

   - The operator stands besides the patient.

   Indication

   - Mandibular left molars and premolars of facial areas.
   - Mandibular left molars and premolar of lingual areas.
   - the maxillary left molars and premolars facial areas.
   - Maxillary anterior facial surface.

Rear Position

12 o'clock position the operator stands behind the patient:

- Lingual surface or maxillary and mandibular anterior teeth.
- Lingual and facial surfaces of mandibular left molars and premolars.
- Lingual surface of the right, left maxillary premolars and molars.

– Facial surface of right maxillary premolars and molars.

In Sitting Position

– Chair has to be adjusted so that patient and operator is comfortable as well as provide a position to completely visualization in all area of oral cavity.
– For right handed operator the position is 11, 12 o'clock.
– For left handed operator one and second o'clock.

Maximum Visibility

Importance of Visibility

The detection of calcareous deposition, any distinct changes on the tooth surface and anamolies of teeth structures that require adjustment in instrumentarium.

– To visualize the cutting edge of the instrument when operating in deep periodental pocket.
– To watch the trauma to the teeth while operating.

Accessibility

– Maximum effectiveness
– Maximum convenience to the patient
– More co-operation of the patient.

ILLUMINATION

a. Direct illumination is most desirable and most convenient.
b. Indirect illumination is used by reflecting the light with a mouth mirror, when direct illumination is not possible. This will facilitate:
   – Maximum visibility of all the areas in oral cavity.
   – Maximum accessibility of the operating areas.
   – Better instrumentation.
   – Thorough removal of the calcareous deposits.

RETRACTION

Retraction is obtained by:
1. Cheek retractor
2. Use of mirror to reflect and provide the buccal tissues and tongue.
3. Use of finger of non-operating hand in remote area.

Retraction is Provided by:

1. Better illumination
2. Accessibility, and
3. Visibility

Grasp

– Hold the instrument securely and stabilize the hand for operating stability is essential for controlled action of instrument to avoid injury to patient from sudden movements of operator hand.
– Two factors of major importance in providing stability are:
   1. Instrument grasp
   2. Finger rest

   Instrument grasp

   1. The pen grasp
   2. Modified pen grasp
   3. Palm and thumb grasp
   4. Palm grasp

Sharp Instruments

– Instruments must be sharp to be effective for successful treatment.
– Dull instruments inflict unnecessary trauma.

– Sharpening of instruments can be done with Arkansa's as stone or by rotary method.

Maintain a Clean Field

Isolation and hemostasis of the operating field is essential for efficient treatment, which is obtained by using:

1. Cotton rolls (isolation)
2. 1 : 80000 or 1 : 2,00,000 of adrenaline injection for hemostatis as well as isolation.
3. Zinc chloride 8% useful in hemostasis.
4. Aspirator by suction
5. Rubber dam (isolation)
6. Gauze piece (Dressing)

Be Gentle and Careful

a. To avoid unnecessary discomfort and pain during operating procedure and postoperatively.
b. To avoid excessive bleeding in the field of operation, which will prevent the effectiveness of the operation.
c. To avoid excessive tissue laceration, which retards the healing process.
d. To prevent the infected material from being forced into the deeper periodontal tissues and leading to the post operative infection.

Observe the Patient at all Times

A close check up must be kept on the patient for possibilities of shock, syncope and fits. Make sure the patient keeps his eyes open when treatment is being carried out.

Definite protocol of sequence planned of the over-all treatment should be carried out.

Sterilization and Asepsis

The dental operatory table, light switch and instruments must be clean, sterile and kept aseptic.The table or instrument trolley/tray must be cleaned with spirit before the sterile instrument are a must. The instruments must be arranged in systematic order. Asepsis of the area around the patients mouth also is essential and is done with the application of spirit. Area in the field of treatment is maintained with application of topial iodine, or irrigation of chlorhexidine before the treatment is started.

Care and Consumer Protection

i. Use of clean apron by operator.
ii. Use of proper coverage by disposable drape to patients.
iii. Use of clean, effective, face mask and preferable use double pair of disposable rubber latex gloves by the operator while working.
iv. Skill in communication with patients, oral and written instructions.
v. Maintenance of proper treatment notes and records in filling system.
vi. All the principles of consumer protection must be followed.

17 Differences between Primary and Permanent Dentition

INTRODUCTION

The formation of the teeth, development of dentition, and growth of the craniofacial complex are closely related in the prenatal as well as the postnatal developmental period. At birth, there are usually no teeth visible in the mouth, but many teeth in various stages of development are found in the jaws. The primary dentition removes intact till about 6 years of age, when the transition to succedaneous/permanent dentition begins. The permanent teeth replace the exfoliated deciduous teeth in a sequence of eruption that exhibits great variety.

The importance of eruption of the teeth to the development of oral motor behavior is frequently overlooked. However, the appearance of the teeth in the mouth at such a strategic time in the maturation of nervous system and its interface with the external environment has a profound effect on neurobehavioral mechanisms.

After 37 days of intrauterine development a continuous band of epithelium forms around the mouth from fusion of separate plates of thickened epithelium. These bands are roughly horseshoe shaped – Dental lamina and vestibular lamina.

Within dental lamina, continuous and localized proliferative activity leads to formation of series of epithelial ingrowths at sites corresponding to the position of future deciduous teeth.

Permanent or deciduous dentition arises from dental lamina. The increased proliferated activity leads to formation of another epithelial cap and associated ectomesenchymal response on the lingual aspect of the deciduous tooth germs. Molars of permanent dentition do not have any deciduous predecessor, so a backward extension of the dental lamina occurs which gives off epithelial in growth which together with the associated ectomesenchymal response form the tooth germs of the 1st, 2nd and 3rd molars.

The entire primary dentition is initiated between 6th and 8th week of embryonici development the successional permanent teeth develop between twentieth week *in utero* and 10th month after birth and the permanent molars between 20th week *in utero* for 1st molar to 4th to 4th year of life for the 3rd molars.

Chronological Differences

Primary dentition is present in the oral cavity from 6 months to 12 years of age. This is the time corresponding to the eruption of mandibular central incisor to the time of exfoliation of 2nd molars.

The permanent teeth start appearing in the oral cavity from 6 years onwards. The period from 6 years of age to 12 years of age is called the mixed dentition period.

The chronology of primary teeth is relatively consistent permanent teeth.

Morphological Differences

Deciduous Teeth	*Permanent Teeth*
i. Number – 20	i. Number – 32
ii. Dental formula $I^1/I^1, C^1/C^1, M^2/M^2$	ii. Dental formula $I^2/I^2, C^1/C^1, P^2/P^2, M^3/M^3$
iii. Color is more white (Milky white)	iii. Color varies from yellowish white to grayish white
iv. Crown appears to be bulky in proportion to root.	iv. Crown does not appear so bulky in proportion to roots.
v. Crowns are wider in their mesiodistal diameter as compared to cervico-occlusal height, so crowns have a bulbous appearance.	v. Buccolingual dimension of crowns are more than cervico-occlusal height.
vi. Occlusal table is relatively narrower due to convergence of buccal and lingual surfaces towards occlusal surface (Fig. 17.1)	vi. Occlusal table is relatively wider because the buccal and lingual surfaces do not convergence towards occlusal surface so acutely (Fig. 17.2)
vii. Cusps are taller, sharp and occlusal fossae are deep.	vii. Cusps are comparatively blunt
viii. Cervical ridge is more pronounced	viii. Cervical ridge is less pronounced
ix. Cervix of molars is more constricted	ix. Cervix of molars is less constricted
x. Buccal and lingual surfaces and cervical bulge are less rounded and are more flatter	Buccal and lingual surfaces and cervical bulge are more rounded in molars
xi. CEJ is abrupt	xi. CEJ is not abrupt
xii. Contact areas are wider	xii. Contact areas are small
xiii. Incisal edges of the maxillary lateral incisor are at the same occlusal plane as central incisor	xiii. Maxillary lateral incisor is 1 to 2 mm above the occlusal plane of central incisor
xiv. Mesial slope of maxillary canine is longer than the distal slope	xiv. Mesial slope of maxillary canine is smaller than the distal slope
xv. Roots of primary anterior teeth are narrow mesiodistally (Fig. 17.3)	xv. Roots of anterior teeth are wider mesiodistally (Fig. 17.4)
xvi. Roots of primary anterior teeth curves labially in apical half to accommodate tooth bud of permanent teeth	xvi. Roots of the anterior teeth are wider mesiodistally
xvii. Molar root bifurcation occurs nearer to the crown (Fig. 17.5)	xvii. Molar root bifurcation occurs approximately 4-5 mm from CEJ (Fig. 17.6)
xviii. Roots of molars flare more	xviii. Roots of molars are less flaring
xix. Roots are longer and more slender in comparison with crown size	xix. Roots are less slender in comparison with the crown size
xx. Apical foramina are larger (Fig. 17.7)	xx. Apical foramina are smaller (Fig. 17.8)

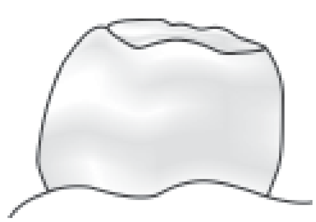


Fig. 17.1: Narrow buccally (occlusal table)

Fig. 17.2: Wide occlusal table

Histological Differences

Deciduous Teeth	*Permanent Teeth*
i. Enamel cap is thinner (1 mm)	i. Enamel cap is thicker at cusp tips (2.5 mm)
ii. In cervical region, it ends up in a marked ridge	ii. In cervical region, it ends up in feather edge
iii. Cervical enamel rods are either horizontal or slightly inclined incisally/occlusally (Fig. 17.9)	iii. Cervical enamel rods incline apically (Fig. 17.10)
iv. Less mineralized and more permeable to ions	iv. More mineralized and less permeable to ions
v. A prismattic surface layer of enamel is 30 m thick	v. A prismatic surface layer is 5 m thick
vi. Enamel rods are less in number due to smaller crown size	vi. Enamel rods are more in number due to larger crown size
vii. Gnarled enamel is absent	vii. Gnarled enamel is present
viii. Neonatal line is present and incremental lines are more rhythmic in enamel (Fig. 17.11)	viii. Neonatal line is absent except in 1st permanent molar. The complete structure of enamel is uniform but not so rhythmic (Fig. 17.12)
ix. The thickness of dentin is less and number of dentinal tubules is also less with tubules being shorter and irregular	ix. Thickness of dentin is more and so is the number of dentinal tubules which are longer and regular in course
x. DEJ is smooth	x. DEJ is scalloped
xi. Pulp chamber is comparatively larger (Fig. 17.13)	xi. Pulp chamber is smaller (Fig. 17.14)
xii. Pulp horns are closer to the DEJ and outer surface of tooth especially the mesiobuccal horn of molars	xii. Pulp horns are not closer to DEJ and the outer surface of the tooth
xiii. Pulp canals are ribbon shaped	xiii. Canals are not ribbon shaped
xiv. Cellular content is usually more than fibrous tissue	xiv. Cellular contact less fibrous tissue in CT of pulp
xv. Zone of Weil is rarely seen	xv. Zone of Weil is more often seen
xvi. Nerve fibres in pulp pass to the odontoblastic area and terminate as free nerve endings. Density of innervation is less	xvi. Nerve fibres terminate among the odontoblasts and may extend even in predentition and the density of innervation is more
xvii. Cementum is thinner and mostly accllular	xvii. Cementum is thicker and it is both cellular and acellular, cellular cemention is predominant in apical 3rd
xviii. PDL is not well developed	xviii. PDL is well developed
xix. Lamina dura is relatively thicker	xix. Lamina dura immediately after eruption is comparatively less thicker
xx. Bony trajectories are fewer but thicker	xx. Bony trajectories are more in member

Functional Differences

1. Presence of oral habits like thumb sucking or finger sucking is more in young children so their effect is more drastic in deciduous dentition and most in mixed dentition.
2. Premature loss of primary molars might lead to development of malocclusion.
3. Primary teeth are natural space maintainers for the permanent successor. Premature loss of primary teeth can result in loss of integrity of the arches. A tooth is maintained in its correct relationship in the dental arch as a result of action of series of forces. If one of these is altered or removed, changes in relationship of

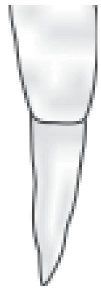


Fig. 17.3: M-D diameter narrow (anterior tooth)

Fig. 17.4: M-D diameter wide

Fig. 17.5: Bifurcation nearer to crown

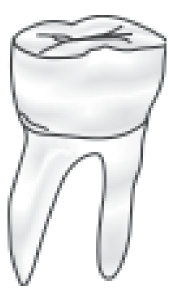


Fig. 17.6: 4-5 mm from CEJ

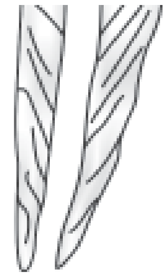


Fig. 17.7: Larger apical foramina

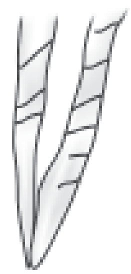


Fig. 17.8: Smaller apical foramina

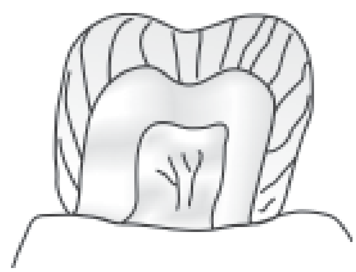


Fig. 17.9: Enamel rod direction

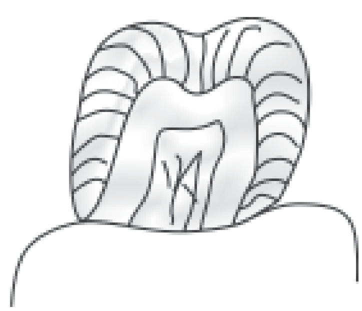


Fig. 17.10: Enamel rod direction

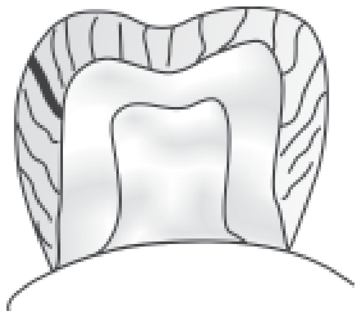


Fig. 17.11: Neonatal line

Fig. 17.13: Enlarged pulp chamber

Fig. 17.12: No neonatal line

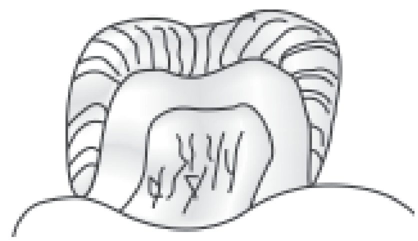


Fig. 17.14: Small pulp chamber

adjacent teeth will occur and development of space problem. Subsequently to these changes, inflammatory and degenerative changes will occur in the supporting tissues.

4. In deciduous teeth, there is presence of flush terminal plane. This is due to difference in the dimensions of deciduous mandibular 2nd molar and deciduous maxillary 2nd molar. In permanent dentition, normally, the distobuccal cusp of mandibular second molar rests in central fossa of maxillary second molar.
5. The occlusal table of deciduous teeth is narrow, alveolar bone is weak as compared to permanent teeth, periodontal apparatus is less well developed, so deciduous teeth are less resistant to the forces of mastication teeth as compared to permanent teeth.
6. One of the important functions of primary teeth is the development of speech. Ability to use the teeth for pronounciation is acquired entirely with the aid of primary dentition. Early and accidental loss of primary teeth may lead to difficulty in pronouncing the sound ‘F’, ‘V’, ‘S’, ‘th’, ‘Z’.

Clinical Considerations

1. *Susceptibility to caries*

- In primary dentition, the sequence of caries attack follows a specific pattern. Mandibular molars are most commonly affected followed by maxillary molars and then maxillary anterior teeth. Mandibular anterior teeth and buccal and lingual surfaces of primary teeth are seldom involved except in rampant caries.

- The 1st primarily molars are much less susceptible to caries than the 2nd primarily molars because the completely coalesce pits and fissures and hence are more susceptible.
- Interproximal caries in primary teeth do not occur until proximal contacts develop. The distal surface of 2nd primary molar is common site for caries after eruption of mandibular 1st permanent molars.
- In permanent dentition, mandibular 1st molar decay earlier and have a higher caries occurrence than the maxillary counterparts. Carious involvement of lower incisors, maxillary permanent central and lateral incisors in minimal except in cases of rampant caries. There is increased susceptibility of caries in the lateral incisors because of presence of development defects like lingual pits or groove.
- The lateral spread of caries takes place at a faster rate in deciduous teeth because of narrow occlusal table.
- Rampant caries and nursing bottle caries are usually seen in deciduous dentition.
- Odontoclasia is a type of linear caries in which the carious lesions are present on the labial surface of maxillary anterior teeth of deciduous dentition corresponding to the neonatal line.
- The frequency of occurrence of pulp polyp is more in deciduous dentition. As the primary teeth have high pulpal vascularity and wider apical foramen, the response of pulp to carious ingression is by proliferative growth of connective tissue.

2. *Periodontal diseases:* Frequency of periodontal disease is less in deciduous dentition due to anatomy and difference in oral flora. As the gingival cervice is shallow in primary teeth, and there are fewer number of anaerobic microorganisms, also the prominent cervical bulge makes the area self-cleansing so PDL disease are few.

Regressive Alternations

Attrition is more in deciduous dentition because of decreased mineralized which leads to softer enamel and dentin. Abrasion and erosion are not commonly found in deciduous teeth because of increased cervical bulge and also due to difference in food and brushing habits.

There is lack of awareness amongst majority of population about the importance of primary dentition, the influence of permanent successors and their role as natural space maintainers.

Clinical Applications in Relation to Conservative Dentistry

Cavity preparation of primary teeth is different from that of permanent teeth because of difference in morphology, pulpal anatomy and direction of enamel rods in cervical region.

Class I Cavity

As the thickness of enamel and dentin is less in primary dentition, the depth of the cavity should be less.

It is 1 mm for 1st molar and 1.5 mm for 2nd molars.

While making the outline form, lateral extensious of the cavity should be less because increase in the extension of cavity may result in weakening of the cusps.

The pulpal wall is slightly concave so as to avoid exposing the pulp horns and the walls shouldbe extended minimally in buccolingual direction.

Class II

The occlusal box should be made similar to class I but extension of outline from depends on the tooth involved. In cases of deciduous upper 2nd molar, the oblique ridge should not be touched until undermined by caries. In the primary 2nd molar (lower) all pits and fissures are to be included.

In primary teeth as the interproximal contacts are broader so, while making proximal box more cutting is required buccolingually so as to keep the margins of the cavity in self-cleansing area. The proximal walls should converge so as to meet at the marginal ridge, while allowing only the tip of an explorer to pass between the margins of the box and the adjacent tooth.

The buccal and the lingual walls in the proximal box should be converging so as to make the cavity retentive. Also, the cavosurface angle needs to be at right angle to ensure maximum strength at the enamel amalgam junction.

Gingival Wall

The width of the gingival wall should be appropriately 1 mm and lie in dentin.

While preparing gingival wall there is increased danger of damaging soft tissues interproximally in deciduous teeth. The gingival wall should not be carried too far gingivally and the floor should be located just below the contact area of the adjacent tooth.

If the caries extends gingivally below the cervical bulge so far that and proper gingival wall cannot be established, it is permissible to round off the proximal box gingivally.

Gingival bevel is not required in deciduous teeth because cervically, the enamel rods are horizontal or point occlusally, so there is little or no danger of rods being unsupported. Relation grooves and locks are not given in the deciduous teeth.

The large decayed lesions in a primary molar offers some difficult problems because of the narrow occlusal table and in these teeth, the proximal walls are easily undermined by a large proximal carious lesion.

Matrix Band

Due to construction of crowns and roots of primary molars in the cervical third and presence of pronounced cervical ridge, there is difficulty in adjustment of the matrix band. Matrix band for primary dentition is of smaller dimension (3/16").

The matrix band should not be secured tightly to the tooth as the greatest circumference is not at the cervix. Therefore, tightening will cause the matrix band to flare out at gingival side and may result in overhang of the restoration.

Class III

Depth of the cavity preparation as kept minimal and beveling at the gingival margin is not done.(G.M.T. not use)

Class IV

Depth of cavity is kept minimal and a shallow groove is given in proximal box.

Class V

Ultraconservative in primary teeth and involves just the removal of carious dentin.

a. *Dentin Sensitivity:* Primary teeth are less sensitive to operative procedures as compared to permanent teeth due to less dense invervation of nerve fibers.

As the primary teeth resorb, there is degeneration of neural elements as with other pulp cells. Neural tissue is the first to degenerate when root resorption begins.

b. *Acid etching:* As a thick layer of aprismatic enamel is present in deciduous as compared to permanent dentition so the time required for acid etching is almost twice that of permanent teeth.

3. *Pulp treatment:*

a. *Direct Pulp Capping* is the protection of pulp exposed by traumatic or in course of excavating deep dentinal caries. Rationale behind it lies on the ability of the young healthy pulp is to initiate a dentinal bridge formation thus walling off the exposure site. The most commonly used pulp capping material is $Ca(OH)_2$. Direct pulp capping has been found to be less successful in primary teeth than permanent teeth. It has been stated that the high cellular content of pulp tissue may be responsible for increased failure rate of direct pulp capping in primary teeth. Undifferentiated mesenchymal cells may differentiate into odontoclastic cells in response to pulp capping material which leads to internal resorption.

b. *Pulpotomy* is the surgical removal of coronal pulp leaving intact the vital tissue within the canals. A suitable medicament is then placed over the remaining tissue in an attempt to promote healing retention of pulp tissue.

Pulpotomy medicaments (Gylutaraldehyde) are commonly use. Gylutaraldehyde is better than formacresol. In glutaraldehyde pulpotomy there is initial zone of fixation adjacent to the dressing. The tissue adjoining the fix zone and down to apex has cellular detail of normal vital pulp.

In formocresol pulpotomy, just beneath the dressing is zone of necrosis, followed beneath by zone of fixation and then is the evidence of pulpal tissue. According to Gravenmade, satisfactory fixation with formocresol requires an excessive amount of medication as well as longer periods of interaction. These requirements may lead to undesirable effects at periapex especially in primary teeth having wide apical foramen.

c. *Pulpectomy:* The removal of necrotic pulp tissue and subsequent filling of the root canals of primary teeth is marked with various controversies. The negative attitude towards primary tooth filling are based on the bizarre and tortuous root canal anatomy. According to Marsh and Largent, the goal of the pulpectomy procedure in primary teeth should be the reduction of bacteria in the contaminated pulp.

d. *Biomechanical Preparation*

i. In single canal primary teeth, BMP is done carefully canal preparation larger than size primary is discouraged. Flaring of canal should be minimal because the roots are short and straight.

ii. In multirooted primary teeth, the canals are quite wide buccolingually but narrow mesiodistally. The roots are more curved. In maxillary 2nd primary molar, the curve of the mesiobuccal root is first to the mesial and then to distal. The curve of the distal root is first to the distal and then to the mesial.

Sometimes the curves are quite severe that the chances of zipping at the apex is always present.

e. *Debridement:* In primary teeth, chemical means are often used in conjunction with limited mechanical debridement to disinfect and remove necrotic material within somewhat inaccessible canals. So copious irrigationwith large amount of irrigant is needed.
f. Obturation, resorbable cements based on either $Ca(OH)_2$, ZnOE, or iodoform are used for root filling rather than solid core materials like gutta percha or silver points.
4. *Tooth preparation for crowns:* The crown may be stainless steel or polycarbonate. Tooth cutting is minimal on all sides. Proximal slicing is done and 2 degree to 5 degree convergence is given. Labial and lingual reduction is 0.5 mm. Incisal reduction is approximately 1 mm.
5. Due to the presence of flared roots in deciduous molars, the extraction of these teeth can be difficult. Moreover, the crowns of permanent teeth are situated in close proximity to the flared roots; so if care is not exercised during the extraction of these teeth, dislodgement of forming succedaneous teeth may occur.

Chronic periapical lesions usually heal after removal of the infected tooth. Curettage of the socket may damage permanent tooth follicle and may cause disturbance in the calcification of enamel of crown.

18 Composites

INTRODUCTION

"Beauty lies in the eyes of the beholder"

The greatest asset of a person can have in life next to humanity is smile. Color will be added to it if he or she is having beautiful natural teeth or naturally appearing teeth.

Hence, beauty or esthetic or in fact esthetic dentistry has played a very major role in the field of dentistry from the last decade.

One of the basic requirements of esthetic in dentistry is to restore anterior teeth and any extraorally conspicuous aspects of posterior teeth, with a restorative material that has the same color, shade and all visual perceptions as that of adjacent tooth structure while keeping them unchanged in function.

There are 5 types of tooth colored restorative materials, silicate cement, unfilled resins, filled resins, ASPA and composite resins.

Dental composites have been considered acceptable restorative materials for anterior application for many years. Their tooth matching ability and lack of metallic mercury have caused them to be promoted as an adjunct to or substitute for dental amalgam in the restoration of posterior teeth.

HISTORICAL DEVELOPMENT

Early attempts at esthetic filling materials which predated acrylic resins and composites were based on silicate cements. Solubility problems with these materials led to the introduction of unfilled acrylic systems based on polymethyl methacrylate (PMMA). Methyl methacrylatle monomer contracted excessively during polymerization leading to marginal leakage. Also PMMA was not strong enough to bear occlusal loads. Therefore reinforcing ceramic fillers, principally containing silica were added. Retrospectively the original PMMA materials were called unfilled acrylics.

MMA-based matrices were supplemented by BIS-GMA. It is a disfunctional monomer produced as the reaction product of Bisphenol-A and glycidyl methacrylate. Another very similar disfunctional molecule used is urethane dimethacrylate (UDM). Both BIS-GMA and UDM are highly viscous. For practical reasons, they are diluted with another disfunctional monomer, triethylene glycol dimethacrylate (TEGDM) of much lower viscosity.

It is very important to provide interfacial bonding between the matrix phase (BIS-GMA) and the dispersed phase (fillers), to gain full advantage of the composite formulation. Silica particles are pre-coated with mono-molecular films of silane coupling agents. These molecules are disfunctional. One end is capable of bonding to hydroxyl groups, which exist along the surface of the silica particles and the other end is capable of co-polymerising with double bonds of monomers in the matrix phase.

Filler compositions are often modified with other ions to produce desirable changes in properties. Lithium and aluminium ions make the glass easier to crush to generate small particles. Barium zinc and boron ions have been used to produce radioopacity.

COMPOSITION

Definition

A composite material is a three dimensional combination of at least two chemically different materials with a distinct interface separating the components. A composite resin generally consists of three phases.

Matrix Phase

The main component of the organic matrix of all composites is an oligomer. The most common are Bis-GMA. Urethane-diacrylates, a modified Bis-GMA and TEG-DMA (triethylene-glycondimethacrylate). Bis-Gma is a very viscous dimethylene glyco-dimethacrylate as a diluent to produce a 'workable' resin. Viscosity controllers and inhibitors are usually added to improve the handling properties and self life.

Surface Interfacial Phase

The surface interfacial phase consists of either a bipolar coupling agent, usually an organo-silane connecting the organic resin matrix and the inorganic fillers, or a copolymeric or homopolymeric bond between the organic matrix and partially organic filler. The magnitude of the interface adhesion and its chemical stability is crucial to the clinical properties of any class of composites.

Dispersed Phase

This may consist of either one or a combination of the following:

Microceramics

This is the reinforcing phase of the first regeneration composite resins, and consists of silica-silicate (SiO_4) based materials. Examples of these in use are quartz, fused silica, silicate glasses, crystalline lithium aluminium silicate, barium aluminium – boro-silicate etc. Those that contain heavy metals (barium) will be radiopaque. Although original particle diameters were between 5 and 75 micrometers, today they are reduced to between 1 to 5 micrometers. They are produced from larger particles by crushing and grinding, which produces irregularly shaped particles.

To improve the surface texture and packing factor of the final materials, a decrease in the surface irregularity through more sophisticated grinding techniques, and use of different size particles, mathematically calculated to occupy the maximum available space, as well as use of softer ceramics have all been incorporated into today's conventional composites.

Colloidal and microceramics

These comprise the reinforcing phase for the second generation of composite resins. Originally, these fillers were colloidal silica in the form of silicic acid, formulated by a chemical process of hydrolysis followed by precipitation. To be in the colloidal state, the diameter of these particles cannot exceed 0.04 micrometers. Recently, parts of these particles have been replaced with larger particles of pyrogenic silica, with an average diameter of 0.65 to 0.1 micrometer. In either of these dimensions, the particles are smaller than the wavelength of the visible light; consequently they gave the final product an extremely smooth surface. Because of the large surface area resulting from such dispersed phases, the viscosity of systems utilizing them will be very high.

Therefore, there is a limit to the dispersion of these types of particles if a workable system is to result. The maximum percentage of such dispersion to maintain reasonable workability, is 50% dispersed phase by volume and 30% by weight.

Fabricated Macro-reinforcing Phases with Colloidal Microceramic Component Bases

In an attempt to reinforce composite systems more with colloidal or microceramics, without interfering with the workability of the material, several procedures are indicated.

Pyrogenic silica and silicic acid (colloidal state) are dispersed in a resin system as the continuous phase. This will cause viscosity to be very high, as the system is loaded to its maximum capacity with the dispersed microcoloidal particles. The system is then heat-cured. The created mass is then ground into small, irregularly shaped particles, ranging in size from 1-200 micrometers. These highly filled particles could then be used as a dispersed phase in a continuous resin phase that may be cured photochemcially or chemico-chemically.

Colloidal or microceramics are introduced into partially thermo-chemically polymerized spherical particles of a resin system. The diameter of these spheres may range from 10-30 micrometers. The highly reinforces spherical resin particles are then used as reinforcers for a continuous phase resin, forming a composite resin.

Using a sintering process of heat and pressure, the colloidal micro-ceramic particles are agglomerated to form irregularly shaped and sized, highly porous particles. These range in size between 1-25 micrometers. Dispersing these agglomerated particles into a suitable continuous phase resin, to be photochemically or chemico-chemically cured, will create the most highly reinforced composite.

The interface between the interrupted and the continuous phase is the most crucial in determining the final behavior of these systems. Usually the interface is enhanced by a coupling agent in the form of a bi-polar molecule (usually organo-silanes and their derivatives). These agents are ionically and physically bonded to the inorganic parts of the reinforcing particles, and chemically and physically bonded to the inorganic and organic parts of both the continuous and interrupted phases. On the other hand, this interface may be a co-polymeric or homopolymeric bonds (covalent and physical) between the organic matrix and the partially organic dispersed phases.

The better the bonding at these interfaces, the more the reinforcing phases that may be added, enhancing the physical and mechanical properties of the composite. Modifiers are added to the mass to create certain effects or characteristics. For example, hydroquinone 0.008% (monomethyl ether) stabilizes the resin, preventing undue polymerization (polymerization retarder); coloring agents, usually in the form of inorganic oxides, or sulfides, establish certain visual effects in the material; ultraviolet light absorbers prevent discoloration of the resin due to ultraviolet rays.

CLASSIFICATION

Composite resin can be classified in various manners. Different authors have based their classification on different criteria. Viz. (1) On the basis of their evolution (generation), (2) On the basis of size, amount and composition of the inorganic filler, (3) based on the polymerization methods.

a. *First generation composites:* Consists of macroceramic reinforcing phases in an appropriate resin matrix. This type enjoys the broadest clinical experience, has the highest mechanical properties in lab testing, and the highest proportion of destructive wear clinically due to the dislodging of the large ceramic particles. The first generation composites have the highest surface roughness, newer versions of these materials, with smaller, softer, more rounded particles of variable dimensions have reduced these drawbacks tremendously.
b. *Second generation composites:* With colloidal and microceramic phases in a continuous resin phase, exhibit the best surface texture of all composite resins. However, the properties of strength and coefficient of thermal expansion are unfavourable that can be added without increasing viscosity beyond the limits of workability.
c. *Third generation composite:* Is a hybrid composite in which there is a combination of macro and micro (colloidal) ceramics as reinforcers. They exist in a ratio of 75:25 in a suitable continuous phase resin. As may be expected, the properties are somewhat of a compromise between the first and second generation materials.
d. *Fourth generation composites:* Are also hybrid types, but instead of macroceramic fillers, these contain heat cured, irregularly shaped, highly reinforced composite macro particles with a reinforcing phase of micro colloidal ceramics. Although these materials do produce superior restorations they are very technique sensitive.
e. *Fifth generation composites:* are a hybrid system in which the continuous resins phase is reinforced with micro-ceramics (colloidal) and macro, spherical, highly reinforced, heat cured composite particles. The continuous phase of these particles is the same as (chemically bondable with) the final composite continuous phase. The spherical shape of the macrocomposite particles will improve their wettability, and consequently, their chemical bonding to the continuous phase of the final composite. Furthermore, because of the specific shape of the macromolecules, the workability is improved.

   From this micro-structural description, it should be apparent that the surface texture and wear of these materials would be comparable to that of the second generation composite systems. Physical and mechanical properties are similar to those of the fourth generation materials.
f. *Sixth generation composites:* are hybrid types in which the continuous phase is reinforced with a combination of micro-(colloidal) ceramics and agglomerates of sintered micro (colloidal) – ceramics. This type of composite exhibits the highest percentage of reinforcing particles. Of all composites, it has the best mechanical properties. Its wear and surface texture characteristics are very similar to fourth generation systems. Also it exhibits the least shrinkage, due to the minimum amount of continuous phase present, and also due to the condensable nature of these systems.

Composite resins may be supplied in one of six systems:

1. *Chemically cured paste-paste system:* Each paste contains the monomer of the continuous phase as well as the dispersed phase treated particles. Only one paste contains the initiator. The other contains the activator (accelerator) and coloring

agents. Base contains Bis-GMA and benzoyl peroxide initiator. Catalyst based contains an organic amide accelerator in addition to Bis-GMA.

2. *Chemically cured or photocured liquid powder system:* The liquid in this system contains the monomer of the dispersion phase resins, with the accelerator (activator) and photon energy absorber and convertor. The powder contains the polymer of the dispersion phase, the particles of the dispersed phase, the initiator and the coloring agents. Powder contains siliceous fillers, pigments, and catalyst, liquid consists of Bis-GMA. In some systems the viscosity of the liquid resin is reduced by adding methacrylate monomer.
3. *Chemically cured or photocured paste – liquid system:* The paste in this system contains the monomer of the dispersion phase, the particles of the dispersed phase, the initiator, and colouring agents. The liquid contains the monomer of the dispersin phase, the activator (accelerator), or ultraviolet visible light energy absorbers, and a convertor to activate decomposition of the initiator. When the paste is mixed with the liquid, the benzoyl peroxide will be decomposed chemically or by the application of the visible or ultraviolet light rays and this will precipitate the polymerization of the continuous phase. Liquid is added to paste, in this system, in an effort to vary the viscosity of the mix, as required by different restorative situations. Paste contains Bis-GMA, filler, shading pigments and catalyst. Liquid contains the accelerator.
4. *Photocured one paste system:* The paste in this system is provided in varying viscosities and contains the monomer of the dispersion phase, treated particles of the dispersed of ultraviolet or visible light rays. This last chemical polymerization of the dispersion phase.
5. *Photo-cured one liquid system:* This consists of a highly viscous liquid that contains all the ingredients found in the one paste system, but with a lower percentage of reinforcing phase. It is usually used in intricate areas of cavity preparation where high wettability is needed.
6. *Chemically cured three or four part system:* The main powder part contains the polymer of the dispersion phase, the dispersed phase particles, and coloring agents. The main liquid part is the monomer of the dispersion phase. A third part, consisting of the initiator, and a fourth part consisting of the accelerator, the supplied separately. Sometimes the second and third parts are supplied together, and are to be incorporated with the fourth and first parts just before the mixing. The final structure of composite resin produced by anyone of the above mentioned systems is a classical, reinforced composite material influencing its clinical behavior.

Composite resins are also divided based primary on the size, amount and composition of the inorganic filler as given by Sturdevant; (1) conventional composites resins, (2) microfilled resins, and (3) hybrid composite resins.

Conventional composite resins: Conventional composites generally contain approximately 75 to 80% inorganic filler by weight. The particle size usually ranges from 5 to 25 um with the average being approximately 8 um. Because of the relatively large size and extreme hardness of the filler particles, conventional composites typically exhibit a rough surface texture.

Microfilled resins: In the late 1970's, the microfilled resins or "polishable composites" were introduced. These materials were designed to replace the rough surface characteristic of conventional composite resins with a smooth, lustrous surface similar to tooth enamel. Instead of containing large filler particles typical of the conventional composites, the microfilled resins have submicron-sized particles of colloidal silica whose average size ranges from 0.01 to 0.04 um. This small particle size results in a smooth, polished surface in the finished restoration that is less receptive to plaque or extrinsic staining. Typically, microfilled resins have an inorganic filler content of approximately 35 to 50% by weight, because these materials contain considerably less filler than do conventional composite resins, their physical characteristics are somewhat inferior.

Hybrid composite resins: In an effort to combine the good physical properties characteristic of conventional composites with the smooth surface typical of the microfilled resins, the hybrid types of composite were developed. These materials generally have an inorganic filler content of approximately 70 to 80% by weight. The filler consists of particles somewhat smaller than those found in conventional composites along with submission sized particles found in mocrofilled resins. Because of the relatively high content of inorganic fillers, the physical characteristics are similar to those of conventional composites. Also, the presence of submicron-sized particles interspersed among the larger particles allows a smooth surface texture to be attained in the finished restoration.

Polymerization Methods

Based on this they are classified into; (1) self-curing composites, in which the polymerization process is activated by chemical means; and (2) light-activated composites, in which polymerization is achieved by a photochemical reaction. Regardless of the polymerization process, the composition of the resulting material is basically the same.

Self-curing composite resins: Self-curing composite resins are most commonly available as a two paste system composed of a catalyst and a base material. One part contains an organic amine accelerator, and the other part includes a peroxide initiator. When these two components are properly mixed the polymerization process is chemically activated, although the amounts of catalyst and base materials are usually mixed in a ratio of approximately 1:1, variations in the ratio of as much as 2:1 of either component to the other can be used to vary the working and wetting times without significantly altering the physical characteristics of the set material.

Light activated composite resin: By incorporating photochemical initiators, composite resins can be polymerized by either ultraviolet (black) or visible (white) light. The presence of benzoin methyl either in the composite resin results in the initiation. Photochemical initiators such as diketones have since been found to initiators such as diketones have since been found to initiate polymerization in absorbing visible light in the range of 420 to 450 nM. Both the ultraviolet and visible light activated composites offer many advantages over the self-curing composites, including extended working time, reduced porosity, and better resistance to wear or abrasion.

The ultraviolet light activated systems have several disadvantages of primary concern is the potential health hazard to clinical and patients posed by ultraviolet radiation. The possibility of retinal and soft tissue damage from direct ultraviolet radiation raised doubts regarding the safety of these systems. Furthermore, practical disadvantages exist with ultraviolet light generators require several minutes of warm up time before being fully operable, approximately 60 seconds are required to care the composite material to a depth of only 1½ mm, and the intensity of the light source gradually decreases in strength with use.

Visible light activated systems provide numerous advantage over ultraviolet light systems; (1) the health hazard is virtually eliminated; (2) no warm up time is required for proper operation; (3) the composite resin material is cured in less time, (20 to 30 seconds greater thickness and opaque and dark shades requiring more time) and to a greater depth (2 to 2½ mm) when compared to the ultraviolet light systems; and (4) there is no decrease in the strength of the light source because the output is constant until the bulb burns out. These advantages have made the visible light system preferable to the ultraviolet systems. Visible light system have greatly facilitated the use of composite resins for restoration and other innovative application.

Classification of composites based on the range of filter particle size has been developed by several authors.

According they are;

1. Megafill —>0.5 to 2 mm filler particle size
2. Macrofill —>10 to 100 microns filler particle size
3. Milifill —> 1 to10 microns filler particle size
4. Minifill —> 0.1 to 1 microns filler particle size
5. Microfill —> 0.01 to 0.1 microns filler particle size
6. Nanofill —> 0.005 to 0.01 microns filler particle size

Composite with mixed range of particle size are called hybrid and the largest particle size range is used to define the hybrid (e.g. minifill hybrid) if the composite simply consists of filler and uncured matrix material it is classified as homogeneous.

Physical Properties of Composites

1. Polymerization shrinkage:
   - Methyl Methacrylate —> 5%
   - Conventional composite —> 1.2 to 1.3%
   - Microfilled composite —> 1.7 to 2%.
2. Posoristy : 1.8% to 4.8%
   - Decreases with injection technique.
3. Co-efficient of thermal expansion:
   - Average value in the range of 0° to 60 °C in which range liquids are usually composites —> 56 to 70 × 10^{-6} per °C. Conventional composites have a co-efficient of thermal expansion nearer to that of teeth.
4. Thermal conductivity:
   - Composites —> 25-33 x 10^{-4} Cal. Per sec. per cm^2 (^{0}C per cm)
   - Enamel —> 21 x 10^{-4}
   - Dentin —> 18 x 10^{-4}
   - Microfilled composites —> 15 – 20 10^{-4} cal. per cm^2
5. Solubility:
   - Composites —> 0.05 mg per cm^2
6. Water sorption —> 0.6 mg per cm^2
7. Wettability: The contact angle formed by a drop of water with composites is the wettability. The contact angle is 65° on composite (hydrophilic).

   The contact angle of water on enamel is 55°.

Mechanical Properties

1. Compressive strength —> 170-260 Mpa
2. Compressive fatigue limit —> 120 – 160 Mpa

3. Tensile strength —> 30 – 40 Mpa
4. Yield strength —> 140 – 160 Mn/m^2, 20000 to 30000 psi
5. Transverse strength —> 90 – 100 Mpa
6. Shear strength —> 48 to 79 Mn/m^3; 7000 to 11000 psi
7. Elastic modulus—10-16 Gpa
8. Poisson's ratio—0.24 to 0.30
9. Modulus of resilience—0.07 – 0.09 Kg-mm/mm^2
10. Fracture toughness —> 0.01 – 0.05 Kg-mm/mm^2
11. Rockwell hardness—100-116 H
12. Indentation depth—55-70 micrometers
13. Recovery from indentation —> 70 to 85%
14. Wear—6-7 x 10.4 mm^3/mm travel.

Biological Consideration

Concerns about biocompatibility of restorative materials usually relate to the effects on the pulp. Chemical insult to the pulp from composites is possible if components leach out or diffuse from the material and subsequently reach the pulp. Properly polymerized composites are relatively biocompatible, since they exhibit minimal solubility, and leachable unreacted species are not present in any quantity. However, uncured composites at the floor of a cavity can serve as a reservoir of diffusible component that could induce long-term pulp inflammation. The latter is of particular concern with the light activated materials. If the clinician attempts to polymerize too thick a layer or if the exposure time to the light is inadequate, the uncured or poorly cured material has leachable constituents present adjacent to the pulp.

The second biological concern is associated with shrinkage of the composite during polymerization and the subsequent marginal leakage. The restorative procedure must therefore be designed to minimize the polymerization shrinkage and microleakage.

GENERAL CONSIDERATIONS FOR DIRECT COMPOSITE RESTORATIONS

Indications

The need for an esthetically pleasing restoration is still the predominant indication for using composite materials. However, the strong bond developed between the etched enamel and bonding agent also promotes additional indications for these restorations.

A small tooth defect or carious lesion can be restored more conservatively with composite than amalgam. Furthermore the strong bond established between composite and enamel has the capacity to strengthen remaining, unprepared tooth structure in larger, more extensive restorations.

However, when use of composite is considered in posterior teeth, a careful judgment of potential wear must be made from an assessment of the patients occlusion.

With increasing concerns about the use of amalgam as a restorative material (primarily regarding the environmental effects of disposal, the use of composite continues to increase).

ACID ETCH TECHNIQUE

The problem of microleakage is more acute with the restorative resins than it is with any other type of material. Most provide some mechanism to counteract marginal leakage. For example, amalgam forms corrosion products along the tooth restoration interface to form a mechanical seal, fluorides are present in some materials and thereby inhibit secondary caries.

One of the most effective ways of improving the marginal seal and mechanical bonding is by use of the acid etch technique. It has markedly expanded the use of resin based restorative materials. This technique, which provides a strong bond between resin and enamel, forms the basis for many innovative dental procedures such as resin bonded metal retainers, porcelain laminate veneers, and orthodontic brackets. It also solved, to a large extent, the previous problems that plagued resin based restorations, namely marginal leakage and staining.

The process of achieving a bond between enamel and resin based restoratives involves discrete etching of the enamel in order to provide selective dissolution, with resultant microporosity.

Etched enamel has a high surface energy, unlike the normal enamel surface, and allows a resin to wet readily the surface and penetrate into the microporosity. Once the resin penetrates into microporosity, it can be polymerized to form a mechanical bond to the enamel. These resin “tags” may penetrate 10 to 20 um into the enamel porosity, but the length is dependent on the etching time.

A number of acids have been used to produce the required microporosity, but the universally used acid is phosphoric acid at a concentration between 30 and 50%, with 37% being the concentration most commonly provided. Concentrations greater than 50% result in the formation of a monocalcium phosphate monohydrate that inhibits further dissolution. Although aqueous solutions are available, generally the etchant is supplied in a gel form to allow control over the area of placement. Brushes are used to place the material, or the acid is supplied in a syringe from which it can be dispensed onto the enamel.

Originally, the length of application was set to 60 seconds, but numerous studies have now shown that 15 seconds provides as strong a bond. However, the application time may vary somewhat, depending on the particular history of the tooth. For example, a tooth with a high fluoride content via a fluoride water supply may require a somewhat longer etch time.

Once the tooth is etched, the acid should be rinsed off thoroughly with a stream of water for about 15 seconds, and the enamel dried completely. When the enamel is dry it should have a white, frosted appearance, which is indicative of a successful etch. This surface must be kept clean and dry until the resin is placed onto if a good bond is to form. Even momentary contact of saliva or blood can prevent effective resin tag formation and severely reduce the bond strength. If contamination should occur, the contaminant should be rinsed off, and the enamel dried and etched again for 10 seconds.

It has been shown that drying the enamel with warm air or using an ethanol rinse can increase the bond strength, which suggests that moisture may still be trapped in the micropores even when the surface appears dry.

POSTERIOR COMPOSITES

Indications

The use of composite resin for posterior teeth should be considered when esthetics is a primary factor and the occlusal pattern of contact is favourable. A summary of indications follows;

1. Class V defects: (a) hypoplasia; (b) hypocalcification that is esthetically objectionable or is cavitated; (c) carious lesion that is cavitated; and (d) abrasion and erosion that is uncontrollably sensitive, excessively deep (threading the integrity of the tooth), or esthetically objectionable.

2. Class VI cavities (faulty pits on selected occlusal cusps).
3. Class I cavities that preferably do not involve centric holding areas.
4. Class II cavities subject to occlusal considerations and/or provision for centric stops.
5. Veneers for metal restorations.
6. Repair of fractured areas (teeth and/or restorations).
7. Interim restorations.

Contraindications

Composite resins are not recommended for posterior restorations under the following conditions.

1. For individuals who generate heavy occlusal stresses by habits such as bruxing or biting hard objects.
2. For class I and class II restorations that are subjected to high stress.
3. When centric holding areas are involved.
4. For deep subgingival areas that are difficult to properly isolate.
5. When oral hygiene is poor.

Advantages

Advantages of composite resin restorations for posterior teeth are as follows:

1. Esthetics – natural initial appearance
2. Conservation of tooth structure
3. Strengthening of the remaining tooth structure
4. Low thermal conductivity
5. Completion in one appointment
6. Materials readily available
7. Economics – relatively inexpensive as compared with gold restoration or porcelain crown
8. Absence of mercury vapours, tarnish, corrosion, and galvanic currents associated with amalgam restorations

Disadvantages

Unfortunately the following features of present posterior composite resins leave much to be desired:

1. A greater coefficient of thermal expansion than that of tooth structure
2. Low modules of elasticity
3. No anticaries factor
4. Porosity
5. Need for pulp protection
6. Difficulty in inserting and finishing (technique sensitive)
7. Low wear resistance in high stress areas, which may result in a change in tooth position and occlusal relationship

General Considerations

During treatment planning the patient should be informed that (1) amalgam or gold restorations have a history of providing an excellent service for many years, whereas composite resins may need to be replaced in a few years, and (2) amalgam or gold restorations have the strength and wear resistance to support occlusion in high stress areas, whereas a change in occlusion may result from wear of the composite resin unless provisions are made to offset this problem.

It is important that the occlusion be evaluated preoperatively to determine the bite relationship and type of occlusal function. patients whose teeth have heavy wear facets, craze lines, cracks, and fractures are not good candidates for posterior composite resin restorations. Teeth that show little or no sign of abuse have a more favorable prognosis. To maintain proper vertical dimension, centric holding contacts should be located on stable areas of sound tooth structure or on some type of restorative material that has a wear rate similar to that of tooth structure. The location of centric stops should be marked with articulating paper. If a composite resin is placed in a centric holding area and wear occurs, a small amalgam or gold restoration should be inserted to maintain the proper occlusal relationship.

A very exacting technique is required to properly insert a posterior composite resin. Extrinsic stains and debris are removed with a slurry of pumice. The shade of the composite resin must be selected preoperatively because of color changes that occur in the teeth as a result of dehydration during operative procedures. An exact shade match is not as critical for the posterior teeth as for the anterior teeth. Actually a slight mismatch makes postoperative evaluation easier. Isolation is best accomplished with a rubber dam; however, cotton rolls may be used in some instances.

Prerequisite Procedure before Cavity Preparation for Composite

a. Evaluate occlusion to determine bite relationship and type of occlusion junction
b. Observe for any weardefect, craze lines, fracture line on the tooth to be restored as there are signs of high occlusal stresses
c. Isolation of the operating site by rubber dam to prevent saliva and debris contamination
d. If needed obtain adequate anesthesia
e. Remove all extensive stains/debris
f. Select the appropriate shade of composite to be used.

Cavity Preparation Design

a. Conventional preparation design: (Fig. 18.1) They are similar to conventional cavity preparation design for class I and II amalgam restoration. Box like cavity design will have slight converging external walls towards the occlusal surface, flat grooves and undercuts in dentin for retention form.

   This design is employed when a existing amalgam retention is replaced with composite restoration.
b. Beveled conventional preparation design: (Fig. 18.2)

   In this the enamel cavosurface is beveled especially in the facial and lingual walls of the proximal box of class II preparation. This provides more surface area for bonding this improving retention. It also reduces leakage and also protects the remaining tooth structure.

   The bevel is placed at a 45 degree angle to the external enamel surface and is 0.5 mm inches.

On existing amalgam restoration

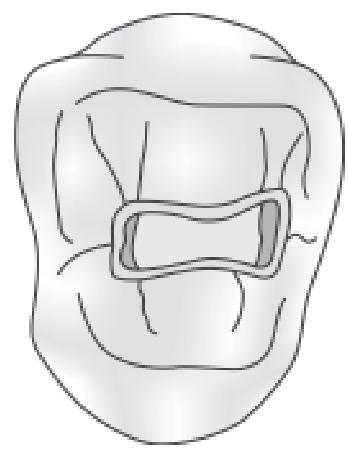


Fig. 18.1: Conventional cavity

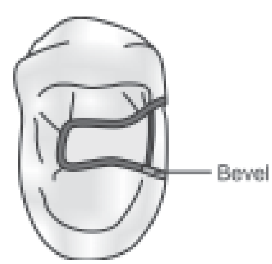


Fig. 18.2: Beveled conventional preparation

c. Modified preparation design:
   In extremely involved teeth the design of cavity preparation is indicated by the extent of the lesion or defect.

   This preparation is characterized by (a) conservative removal of only objective or carious tooth structure (b) establishment of bevel configuration on all cavosurface margin (c) most extensive cavities have incorporative unique feature like reverse bevel secondary flares and brace type skirting at the axial wall.

This type of preparation is not used routinely.

Class I Cavity Preparation for Composite Technique

1. In case of tooth with the rubber dam/ cotton rolls and enter the faulty pit with a small round bur no ¼ or ½ perpendicular to the surface. Extend the preparation pulpally to eliminate the lesion, extend the preparation in all directions to place the cavity walls in sound enamel/dentin. Prepare a small bevel on the enamel cavosurface margin.

   If any stains are present in the preparation it is advised to remove it as it may be seen through if left behind.
2. In maxillary premolar isolate the tooth, enter at one point of the caries fissure with a small round bur. The initial cavity depth is kept in enamel approximately at 1 mm. Extend the cavity till the end of discolored fissure. If caries is little deeper remove all the infected dentin. If a hard dark line persist that is not penetrable by the explorer tip it is left as seen. Smoothen the pulpal flow. Prepare bevel on the cavosurface margin.
3. In molars, evaluate occlusion before cavity preparation. Isolate the tooth. Enter the carious fissure at a point perpendicular to the surface. Extend the preparation to involve all the caries till the termination of the involved fissure.

If caries is extensive excavate injected dentin using high speed revolving round bur or spoon excavator depending on the depth of excavation place calcium hydroxide base for pulp protection.

Place a bevel on enamel cavosurface margin.

In the case of maxillary molar if caries involvement is limited to one pit. Cavity preparation is conservative without involving the oblique ridge.

Class II Cavity Preparation Technique (Fig. 18.3)

Evaluate occlusion before starting cavity preparation. Isolate the area with rubber dam and cotton roll. If the class II preparation involve mesial surface of first molar or premolar. Select the appropriate shade. Place a wedge in the gingival proximal region.

Using a No. 245 bur enter the carious lesion in the central pit or the area adjacent to the proximal lesion. Enter upto a depth of about 1 mm. Extend the preparation to involve all caries and extend it till the termination of the carious involvement. At the involved proximal surface enter by a ditch cut gingivally. Extend it beyond the

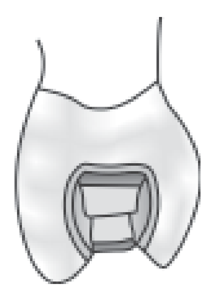


Fig. 18.3: Class II cavity

carious lesion or contact width. More the bur towards the proximal surface and weaken the proximal enamel. Remove the isolated enamel using a spoon excavator or hatchet. Now the proximal box is prepared. Smoothen the enamel wall and trim unsupported enamel rods with enamel hatchet.

Remove any remaining infected dentin or defective enamel. If needed provided appropriate pulp protection by means of liners or base. Place bevel on the occlusion and proximal cavosurface margin. Inspect the cavity after rinsing.

Extensive Class II Cavity Preparation

Preparation of cavity is similar to conservative one but all extensive caries is removed and infected dentin excavator from the pulpal floor. Place protective base and liner and remove all the weakened tooth structure. Undermine enamel can be left intact at the composite resin can support the tooth structure remaining. If need place a bevel or place skirts on the surface. It is favorable to give a secondary flow in the mesiofacial surface of maxillary molar and premolar. This designed all together help composite to brace around the tooth to resist fracture.

Difference between cavity preparation for Composite in class I and class II situation from amalgam

a. The intercuspal width of the preparation for composite is smaller than that of amalgam.
b. If possible surrounding walls pulpal floor and gingival floor can be placed in enamel for composite restoration where it is to be in dentin for restoration of amalgam restoration.
c. In cavity preparation of composite under mined enamel if any can be left as such because it helps in bonding. But in amalgam preparation all enamel wall should be supported by dentin.
d. Cavity preparation for composite does not require a reverse curve at the occlusoproximal junction as it is more esthetic but reverse curve to be given in amalgam for esthetic consideration.
e. For thinned cusp elements circumferential skirting is indicated in cavity preparation for composite but not for amalgam preparation.
f. In amalgam preparation the enamel cavosurface margin is a butt joint as amalgam has low edge strength but in composite preparation bevel can be placed in enamel as it enhances bonding.
g. In cavity preparation for composite the internal line angle and point angle are extremely rounded particularly if they are in enamel.

Class I and Class II Restoration for Composite

Acid etching: This is a procedure of removing the enamel smear layer and obtaining micromechanical retention for resin restoration.

Developed by Buonocore (1955)

Basically the technique consists of applying a solution or gel of 30-50% phosphoric acid to the enamel for 30-60 seconds followed by through rinsing and drying of the area.

The acid solution affects the prismatic structure of the enamel by preferential removal of either the prism core or periphery. Thus, it results in enamel surface with numerous microscopic irregularities, so when a resin of low viscosity is applied to such surface it flows into these cuts and undergoes polymerization to form resin enamel micromechanical bond.

The preparation of resin into these enamel imperfections is called resin tags. This enhances marginal integrity and reduces microleakage along with better retention. Another significance of this is improvement of esthetics as the butt joint is eliminated. Effects of acid etching on surface of enamel (35-50% phosphoric acid).

a. Preferential dissolution of interprasmatic enamel first followed by surface of prisms themselves so the surface area of the enamel will increase upto 2000 times than original surface.
b. So enamel surface will have irregular valleys and depression at an average depth of 25 microns. 1 and 2 increases the retention of the restorative resin which can wet all or most of the irregularities (Low Viscosity).
c. It will expose proteinaceous organic matrix on enamel which adds to retention of the restorative material if it gets embedded in the resin matrix.
d. This aids in removal of substrates, enamel cuticle, salivary deposits and plaque components thus giving a cleaner, less contaminated wettable enamel surface for better adhesion with the resin.
e. Removal of surface enamel results in sufficient surface energy to facilitate reaction with and adhesion of restorative material to the applied.
f. Enamel treatment results in a surface with a highly polar phosphate group which increases the adhesive ability of the enamel surface.
g. It has been suggested that there is precipitation of calcium oxalate and organic tungstate complexes on the surface which adheres both to enamel and resinous substance.

Procedure for Acid Etching (Fig. 18.4)

Isolate the operating site preferably with a rubber dam or use cotton wool and retraction cords.

Etchents are available both in liquid and gel form in the concentration of 37-50%. Liquid etchents are preferred when large areas are to etched as in full veneer crown preparation.

Gels can be used for cavity walls, bevels and margins.

Liquid Etchents

They can be applied by small cotton pellets from sponges and brushes.

a. Gently apply the acid to appropriate enamel surface to be restored, keep the excess of 0.5 mm past the anticipated extent of restoration.

   For proximal preparation apply matrix before application of etchants to prevent inadvertent etching avoid flooding of adjacent tooth.
b. Repeat the application of acid every 10-15 seconds to keep the area moist for 30 seconds avoid flooding the surfaces.
c. Rinse the area with water for 10-15 seconds dry the areas for 20 seconds with clean dry air. Properly etched enamel will have a ground glass or frosted appearance. If this is not observed re-etch for additional 30 seconds.

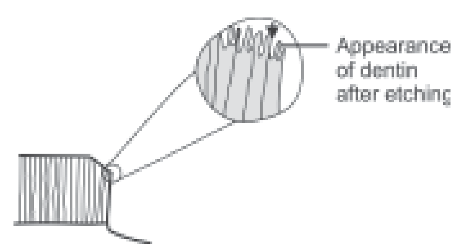


Fig. 18.4: Acid etching

Gel Etchants

They are applied with brush or paper point. The etchant is placed on the cavity walls with the help of instrument or syringe. Leave untouched for 30 seconds, rinse for 20-30 seconds and dry the area with clean dry air for 30 seconds. Re-etch if frosty appearance is not observed after drying.

Dentin Bonding System

These are materials that conditions the dentin to produce a surface that are more retentive. So is used when the preparation extend into dentin.

It consists of primer which is low viscosity hydrophillic resin. This improves adhesion of the resin with the dentins (Hydrated dentinal surface).

After the dentin is primed a low viscosity bonding agent is applied to the dentin. The order of sequence of application is conditioner followed by primer and then bonding agent.

The conditioner removes the smear layer produced by rotary instrumentation. After application of the primer usually a light cured bonding agent is used.

Procedure

The condition is applied in on to the tooth surface to remove smear layer and dental debris. The primer followed by bonding agent is applied. The denebond agent regimes for application depend in the manufacturer direction using paper points, sponges cotton pellets or brushes.

Matricing for posterior composite restoration (Class II).

Composites for class II restoration are totally dependent on the contour and position of the matrix for establishing appropriate proximal contacts.

So selection and proper placement of matrix is important.

An ultra thin metal matrix is preferred for this purpose as it can easily be contoured and is resistant to condensation.

A Tofflemire matrix can be used to restore two surfaces cavity preparation.

A customized compound supported metal matrix is also an excellent matrix for 2 surface composite restoration.

Clear polyester matrices can be used for very small class II preparation. They can be also used with light tofflemire retainer.

Insertion of Composite

They used composite can be either self-cure or light cure material. The preferred are the light cured composite.

a. The material on to the condition cavity using syringes or specialized instruments.
b. The material is inserted in the increment and successively cured. The increment should be approximately 0.5 mm in thickness to facilitate complete curing.
c. Cure the increment for the specified time prescribed by the manufacturer usually 40 seconds provides sufficient polymerization.
d. This is repeated till cavity is filled to slight excess. Cure the last increment and immediately start contouring and finishing the restoration.
e. The occlusal surface is shaped with around 12 bladed carbide finishing burs. Remove excess material from the proximal surface and gingival proximal surfaces.
f. If instruments are used for finishing light shaving strokes are employed to remove excess.
g. Remove the rubber dam and evaluate occlusion. If needed further adjustments

are made and then the restoration finished with fine rubber abrasive points or discs.

In cases of self-cure composite the material is mixed outside and carried to the conditioned cavity in excess and as material set finish the restoration after removal of wedges and matrix.

Methods of insertion of tooth colored material or their components into the preparation:
There are four methods for insertion of the composite into the prepared cavity:

a. Painting technique used primarily for application of acid etchant or dentin bonding system.

   The agent is applied by a brush using light painting action.

b. Brush Bead techniques mainly used for unfilled resins first the liquid is carried to the cavity by a enamel hair brush, a bead of powder is taken and carried to the cavity and then the brush is used to carry the third liquid, thus the restoration build up.

   Curing is done at each increment placement.

c. Bulk pack techniques used mostly for small sized composites. Load the material in syringe and inject into the prepared cavity. It can be also carried to the preparation by suitable instrument.

   Also useful for silicate and GIC insertion.

Materials used for finishing and polishing composites –

a. Finishing burs – carbide burs or extremely fine diamond burs.
b. Descending grades of abrasive paper, preferably aluminum oxide, cuttle, silicon dioxide, disks and strips.
c. Abrasive polishing pastes with glycerine or water using wheel coned shaped brushes, rubber cups, dental tapes.
d. Paste – pumice, tin oxide, alumina, silicon carbide, zirconium silicate, etc.

CLass III Cavity Preparation for Composite Restorations (Fig. 18.6)

Class III cavities are located on the proximal surface of anterior teeth that do not involve the incisal edge.

Composites are mostly used for class II cavities became of its esthetic qualities relative to metallic restorations.

When such cavities are to be restored either a facial or lingual entry can be utilized. The lingual approach is more preferably because:

a. The facial enamel is conserved so better esthetics.
b. Lingual areas is less susceptible to thermal changes.

Indication for facial approach are:

a. Caries superior positioned facially so that facial access conserves more tooth structure.
b. Malignant of tooth which makes lingual approach undesirable.
c. Extreme caries involving the facial surface.
d. When a faulty restoration was originally placed from the facial surface needs replacement.

Convention Class III Cavity Preparation

This is mostly indicated in restoration of root surfaces. The preparation is similar to slot preparation of root caries.

a. Select the appropriate approach
b. Isolate the operating field
c. With a no. 2 or no. 4 burs prepare the initial outline from involve all the caries of the tooth structure and limit the depth pulpally 0.75-1.25 mm depending upon the location.

   The external walls should form a 90 surface. Extend the outline form to acquire convenience form. Then remove any remaining infected dentin using bur on the axial wall. If needed place a line or base. Prepare retentive grooves in the occlusal and gingival wall at axial line angles. They are placed 0.2 mm inside the DEJ. If enamel margins are present (crown area of the placement) place bevel in the cavosurface margin. This promotes bonding by increasing the surface area. Clean the preparation and inspect the cavity.

Bevelled Conventional Class III Cavity Preparation (Figs 18.5 and 18.6)

This can be used to replace defective restoration in crown portion or to restore large carious lesion.

Obtain local anesthesia, isolate the area and select the appropriate shade of composite, determine the approach.

The outline form is prepared with a round carbide bur and enter the tooth at the carious area of restoration by directing bur perpendicular to tooth surface. Extend the outline form to sound to structure by maintaining the depth of axial wall at 0.75 to 1.25 mm. The axial wall should follow the external tooth contour. Prepare the enamel walls perpendicular to the external tooth surface. Finish all the cavity walls with hoe. Remove any remaining infected dentin or old restoration with round bur and/or spoon excavator. Some undermined but non-friable enamel can be left at the margin if present. Apply calcium hydroxide base or liner if indicated. If indicated place a retentive groove on the gingivo-axial line angle with a ¼ bur. The groove should be at a depth of 0.25 mm inside DEJ. The groove is directed primarily gingivally and slightly pulpally. Place a incisal retentive care at the axioincisal point angle. If need, extend the outline form to achieve convenience form. Prepare a cavosurface bevel on the enamel margin using a flame shaped diamand point. The bevel is 0.25-0.5 mm wide. Clean the cavity and inspect the cavity for final approval.

Modified class III Cavity Preparation (Fig. 18.7)

This is indicated for small to moderate sized lesion or fault and should be conservative as possible. The cavity design is indicated by

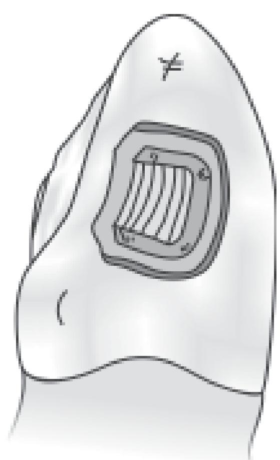


Fig. 18.5: Beveled conventional class-III cavity

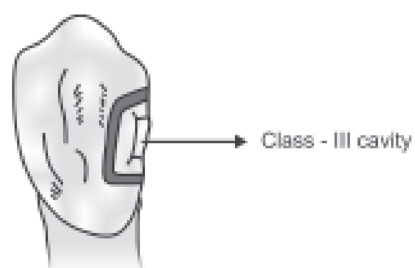


Fig. 18.6: Beveled conventional class III cavity

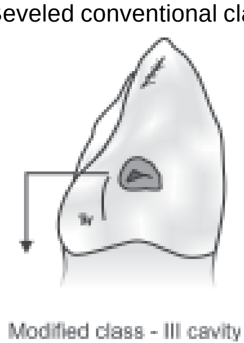


Fig. 18.7: Modified class III cavity preparation

the extend of fault or defect and is usually prepared from the lingual approach. The extension pulpally is also dictated by the extend of caries and is usually not uniform in depth. Thus, the cavity design appears to be sloped and the enamel cavosurface margins are beveled. If the lesion is completely within enamel the cavity preparation is prepared within enamel and retention of composite by bonding with tooth structure. Some undermined enamel which is not friable can be left as such. After initial cavity preparation excavate any remaining caries. Remove infected dentine remaining and if needed apply base or liner as indicated only over the deepest portion of the cavity. Clean the cavity and inspect for facial approval.

Gingival Tissue Management

Gingival tissue management in operative refers to various techniques applied to displace the gingival tissues from the proposed operating site.

It often becomes essential to displace the gingival tissue away from the operating field to carry out the principles of cavity preparation and restoration.

Gingival tissue management can be broadly categorized into:

a. Conservative methods
b. Radical methods

Conservative methods include mechanical tissue eversion and chemico-mechanical tissue eversion.

It refers to the methods of displacement of gingival tissue without removal of any gingival tissue.

Mechanical methods: It refers to the displacement of gingival tissue strictly by the mechanical means. The various techniques are:

a. Usage of rubber dam particularly extra heavy weight rubber dam provide modest displacement of the gingival tissue. This method also controls the flow of gingival sulcular fluid or any gingival hemorrhage. This method also controls the flow of gingival sulcular fluid or any gingival hemorrhage. This method is easy to perform. The degree of retraction depends on the size of the punched holes, spacing between the holes and the type of clamp used.

   The main disadvantage is that it cannot be used in particularly in cases of severe cervical extension.
b. Placement of cotton twills into the gingival sulcus. This is done before starting the operative procedure. The bulk and absorbency of the cotton fibers provide some degree of tissue eversion. This method can be employed where the desired degree of eversion is moderate and incondition where retraction is for short period of time.
c. Placement of wooden wedge in the interdental areas can displace the interdental tissue to a modest degree. This method should be also used for short period of time.
d. Usage of retraction cord impregnated with well tolerated zinc oxide eugenol cement mix the cement in a thin filmy consistency. Take appropriate cotton pills and roll it into mass. Dip into the cement and soak it. Remove the excess liquid by means of towel. Place the impregnated cotton pills into the sulcus by instrument like back of periodontal probe or explorer. On placement of the cord should provide few tenths of a mm of lateral displacement of the gingival margins without producing blanching. If needed one cord

can be placed over the other to produce displacement but in such instances the previously inserted cord should not be displaced by the instrument. To prevent such events the placement instrument should be moved slightly backwards as each step as it is stepped along the cord.

If blanching of gingival margin occur it means there is ischemia due to oversize of the cord. So remove the cord immediately and replace it by a smaller sized one.

Allow the cord to remain inposition for 48 hours. Within this time there will be adequate retraction of the gingival crest. But the cord is never allowed to remain in the sulcus for more than 7 days because it can be led to loss of periodontal attachment.

This method is useful in cavity preparation especially class V and in restoration of cervical abrasion. It can also use for displacing the gingiva before making impression for cast gold crowns or inlays.

Advantages

a. ZOE provides high degree of tissue tolerance
b. It produces effective tissue eversion
c. It gives adequate working time
d. It is also useful in cases of traumatized gingival tissue because of its protective function and ability to promote granulation.

Disadvantages

a Time consuming
b. Another mechanical method is usage of oversized copper bands.

Chemico-mechanical Methods

In this, certain chemicals are employed which aids in tissue retraction.

The chemical employed can be:
a. Vasoconstrictor
b. Styptic
c. Astringent

Retraction cords which can be knitted, braided or loosely woven cotton form are impregnated with drugs.

The most commonly used vasoconstrictor for this purposes is 1:1000 epinephrine or 9% potassium alum.

The retraction cords are placed in the sulcus shrink the tissue by constricting the blood vessels. So there will be local tissue contour reduction. This method is hazardous in patients with hypertension, heart disease, diabetes mellitus and hyperthyroidism.

The astringents used are 5% aluminium chloride for 10 minutes.

100% alum solution for 10 minutes.

Ferric sulfate solution for 3 minutes.

The reduce the tissue size by reducing flow of fluid.

As they have low pH they can cause burns if used in excess.

They styplic used are tannic acid 20% for 10 minutes.

The main advantage of this method is least tissue destruction.

The technique is:
a. Anesthetize the area, which aids in both decreasing salivation and also acts to the patients comforts. Isolate the area with cotton roles or saliva ejector.
b. Select the appropriate retention cord and cut two mm more than that is required. Moisten the cut cord with proposed agent and squeeze the excess.
c. Gradually touch it inside the culcus using discoid excavator or back of probe. If needed place another cord also above it.
d. Don't leave the cord in the sulcus for more than five minutes.

e. If cords are placed in dry form as in medicated cords moisten it before removing to prevent adherence to tissues.

Problems Encounted with this Method

a. Damage the tissue while retraction
b. Hemorrhage
c. Pocket creation

Radical Method

This can be defined as methods of displacement of gingival tissues accomplished by removal of gingival tissue. It can be of two types:
a. Surgical method
b. Chemical method

Surgical Method can be Either

a. Knife surgery
b. Electro surgery: In which high frequency electric current is used 5 types of electrodes are employed.
   i. Diamond electrode
   ii. Coagulative electrode
   iii. Needle electrode
   iv. Small electrode

But this method is not indicated for patient with cardiac pacemaker or neurological problem and in deep gingival margin as there are chances of contacting bone or cementum by the electrode.

The main disadvantage is that the depth of damage cannot be predicted. More chance of tissue injury is there. Another problem is bad smell due to burning of tissue and contact with bone.

Chemical Cauterization

Utilizes certain chemicals like formaldehyde to cause damage to tissues.

Class IV Cavity Preparation for Composites

This is often employed to restore fractured anterior teeth in addition to defective or carious involved incisal edges of anterior teeth.

Three types of preparations are there:
a. Conventional
b. Beveled conventional
c. Modified

Conventional Class IV Cavity Preparation (Fig. 18.8)

Usually do not have clinical application except on those areas of a class IV restoration that have margin located on root surface.

In such case a 90 degree cavosurface margin and retention groove are used in the root portion. The crown portion can be either beveled or modified preparation.

Beveled conventional Class IV Cavity Preparation

This is the commonly used preparation for restoring large proximal areas who do involve the incisal edges. The cavity wall are prepared as much as perpendicular to the long axis of the tooth to prevent fracture of

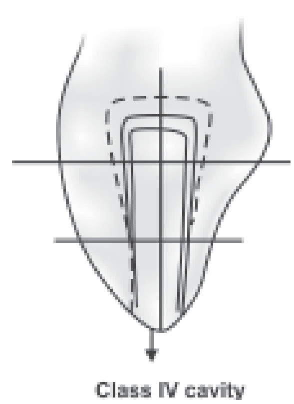


Fig. 18.8: Class IV cavity

the tooth or restorative material due tot biting forces. After initial cavity preparation retention can be provided by placing grooves, undercuts, dovetail extension, threaded pins, or any of these combination. Apply calcium hydroxide base or liner if necessary and bevel the cavosurface margin.

Modified Class IV Cavity Preparation

This is indicated for small or moderate sized class IV lesion or traumatic defects. The objective of such preparation is to remove as little tooth structure as possible while providing adequate retention and resistance form.

Class V Cavity Preparation for Composites

This is often employed to restore lesions on anterior teeth with esthetic considerations, located in gingival one-third of the facial and lingual surfaces.Mostly this is located on root surfaces.

Conventional Class V Cavity Preparation

This is the commonly used preparation for restoring defects that are on facial or lingual root surface.This is present entirely on root. It is recommended for defects extending on root surface and suggests, the enamel margins are beveled conventional or modified while its preparation.

Features

1. 90 degree cavosurface angle
2. Retention forms, sometimes like grooves.
3. Axial line angles at uniform depth.

It is prepared by removing infective dentin or old restorative material on axial walls and then calcium dressing is applied if required. The retention if required is given by grooves which are prepared along the gingivoaxial and incisoaxial line angles.

Beveled Conventional Class V Cavity Preparation

As the name suggests, it has beveled enamel margins and this is designated in cases like replacement of defective class V with initial conventional form, large carious lesions.

Features

1. 90 degrees cavosurface margins
2. Axial wall uniform in depth.
3. Retention if required given by grooves, if axial depth into dentin is 0.5 mm and usually in 0.2 mm, it is not indicated.

This is of more advantage over the conventional the form as it has more retention due to increase in surface area of etched enamel by bevel, bond between composite and tooth is augmented so reduces microleakage, less requirement of retentive features.

It is prepared by removing infective dentin or old restorative material on axial walls and then calcium dressing is applied, only if required. The retention if required is given by gingival grooves, and then bevel the enamel margins.

Modified Class V Cavity Preparation

This is indicated for small or moderate sized class V lesion or traumatic defects. The main aim is conservative restoration to restore the defect. No attept is made for butt joints or retention grooves.

Features

1. Scooped out defect is seen.
2. Preparation is with divergent wall configuration.
3. Axial surface is not uniform in depth.
4. Lesions are entirely in enamel.

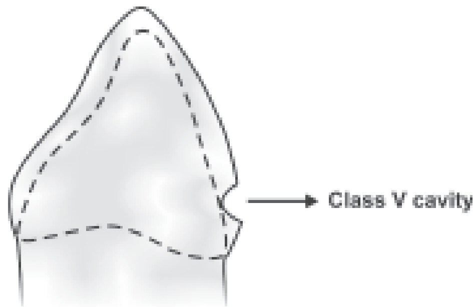


Fig. 18.9: Class V cavity

CONTROVERSIES IN POSTERIOR COMPOSITE RESIN RESTORATION

The use of posterior composites is riddled with so many controversies that the puzzled practitioner must step warily among them. This modality is a minefield, where one careless movement can bring disaster.

All composite restorations are subject to three big destructive forces – moisture, polymerization shrinkage, and clinical wear forces that can eventually produce both microleakage and deterioration of the silane coupling agent linking filler particles to resin matrix. Despite the extreme technique sensitivity of posterior composite resins, knowledge of resin technology, sound operative dentistry principles and foresight in case selection can be effective in producing durable cosmetic restorations.

Posterior composite resin restorations bonded to enamel and dentin reputedly strengthen teeth in both conventional and adhesive types of preparations provided polymerization shrinkage can be controlled. It is imperative that a knowledge of occlusal contacts be used to influence cavity outline, confining the trauma or occlusal forces away from the tooth resin interface and helping to minimize occlusal wear.

With the increased use of posterior resins, the trend in cavity preparations should break away from the traditional black preparation toward the adhesive type preparation. If the black class II preparation is used, it is suggested that bevels be confined to the facial and lingual margins of the proximal box. prewedging helps to maintain a conservative class II preparation.

Shade selection must be made prior to rubber dam isolation for greater accuracy and to help prevent postinsertion discoloration. The enamel should be pumiced to present a clean substrate for acid etching. The smear layer should be removed. The type of pulp protection applied before acid etching is dependent on the material used.

After etching, the enamel should be washed with a 1 percent potassium chloride solution. It is a more universally chemically stable solution than additive laden local water supplies. The potassium chloride solution lowers the electrostatic forces on the enamel that would interfere with the flow of enamel bonding agents. Furthermore, tests have shown that the use of potassium chloride washes increase the strength of the enamel body by 40 percent.

Because of the depth of most posterior cavities, an incremental filling technique must be used to ensure a thorough polymerization of the resin and to forestall a massive polymerization shrinkage.

When finished and contoured, the margins of the restoration should be re-etched, washed, and dried and then covered with an application of unfilled resin to discourage microleakage. Traditional operative dentistry technique must become flexible enough to meet the new demands of resin technology. A change in thinking and willingness to modify conventional procedures can allow dentistry to use this materials to its full potential.

The use of adhesive type cavity preparations and the acid etch system can combine with dentin bonding agents or glass ionomers to successfully insert posterior composites in selected cases. Without a doubt, one of the great disadvantages of posterior composites is the lack of knowledge of many dentists about where or when not to use them.

An understanding of the mechanics of polymerization shrinkage, the elimination of internal moisture, and the role occlusion plays in clinical wear can help to make a more intelligent selection of cases of this type of restorative therapy.

ADDITIONAL USES OF COMPOSITE

Clinical applications of acid etching and synthetic resins presented include; (i) applying pit and fissure sealants, (ii) attaching orthodontic brackets and retainers, (iii) adding tooth contours and contacts, (iv) splinting loose teeth, (v) bonding conservative bridges.

RECENT ADVANCES

Composite Inlays

Resin inlays are polymerized outside the oral cavity and then luted to the tooth with a compatible resin cement to overcome the limitations of post composites.

Direct Technique

- Apply a separating medium (Agar solution or glycerine) to prepare tooth.
- Restoration of resin is formed and light cured and removed.
- The rough inlay is then subjected to additional light (6 minutes) or heat (about 100° C) for 7 minutes.
- Tooth preparation is etched and inlay is luted with dual-cure cement and then polished.

Indirect Technique

- In lab a heat and pressure is employed for polymerization (140°C/85 psi for 10 minutes).
- Homogeneous microfilled resin that has high filler content, less porosity and greater color stability than light activated one.

Advantages

- Higher degree of polymerization is attained.
- Improves physical properties and resistance to wear.
- Polymerization shrinkage occurs outside the tooth so induced stresses are decreased and microleakage is also less.
- Repair is possible in mouth.
- No abrasive to opposing tooth.

CONCLUSION

In the last thirty years no material has received greater attention than the composite resins. Consequently, we have witnessed substantial improvement in both materials and techniques. Dentistry has reached a new era for the aesthetic application of restorations to anterior and posterior teeth. Probably there exists no other dental material with such vast and unique applications as the composite resins. Nevertheless, composite resin are far from ideal, and possess some properties that should be of real concern to the dentist.

The use of composite resin for posterior restoration, adds a new component to dentistry. The material is not an ideal restorative material and has many inherent problems. It is more technique sensitive and less forgiving than amalgam. Therefore posterior composites cannot be considered as a substitute for amalgam. They should instead be considered as a supplementary materials. When used appropriately, composite resins offer the clinician should realize that some compromises are necessary and that there restorations should be very carefully monitored to avoid difficulties with recurrent caries, wear and other complications.

The future is an exciting one and substantial progress may be anticipated in the development of adhesive wear resistant composites. Newer techniques which are simpler than the existing ones and can readily be mastered by not just a few but the majority of dentists are required.

19 Infection Control

INTRODUCTION

Infection control is the multiplication and survival of micro-organisms on or in the body.

The re-emphasis of infection control in dentistry that occurred in the mid-1980s has now resulted in impressive approaches to prevention of disease spread in the office. These approaches are directed toward patient protection and protection of all members of the dental team, so that dentistry has never been safer than it is today for patients and staff alike. Although there is common goal of infection control (to eliminate or reduce the number of microbes shared between people), there are several approaches that may from, one office to the next depending on the type of dental procedures performed, the number and training of employees, office design, the pattern of patient flow though the office, and type of dental equipment used.

The procedures of infection control are designed to kill or remove microbes or to protect against contamination. Because microbes cannot be seen, it is usually impossible to determine of a given procedure is working. For example, have all of the microbes really been killed inside the have all of the microbes has been killed or removed from sterilizer that cleaned and disinfected surface. As result of not being able to confirm immediately the success of infection control procedures as they are being used, one must practice infection control assurance (taking the step necessary to ensure the desired results). Infection control assurance is approached by establishing the proper procedure for a given situation and then routinely perform it correctly in a disciplined manner. This is an extension of the content of sterility assurance to all infection control procedures. Most infection control procedures have been validated for effectiveness when used correctly; when they are misused, however, increased chances for disease spread can occur. This is one reason when infection control procedures frequently have safety factors (overkill) built into help ensure success under a variety of unpredictable conditions. One must be careful, however, not to extend this overkill approach so as to become inefficient.

VIRAL HEPATITIS

Hepatitis B

Viral hepatitis is currently divided into five primary types A, B, C, D (delta), and E. Hepatitis A and B have been recognized as separate entities since the early 1940's and be diagnosed within specific, readily available serologic tests. Hepatitis C, also known as parenterally- transmitted non-A, non-B (PT-NANB) hepatitis, is caused by a virus initially, described in 1988.

Hepatitis D or delta hepatitis, was recognized as an infection dependent on hepatitis B virus. Delta hepatitis may occur as a co-infection with acute hepatitis B infection or as a super infection in a hepatitis B carrier.

Hepatitis E, the epidemic endemic form of non-A, non-B hepatitis, is similar to hepatitis A with a fecal-oral mode of transmission. A 32-34 mm virus like particle was initially described. Although it is more common in men than in women, hepatitis E results in a high fatality rate (10-20%) in women in their third trimester of pregnancy.

Hepatitis B

HBV was first described in 1965. It is a major cause of acute and chronic liver infection, cirrhosis and primary hepatocellular carcinoma world wide. The frequency of HBV infection and patterns of transmission vary markedly throughout the world. In the United States, Western Europe, and Australia, it is an adult disease of low endemicity, and only 0.2 to 0.9% of the population are virus carriers. In contrast, HBV infection is highly endemic in China and South East Asia, Africa, most of the pacific Islands, parts of Middle east, and the Amazon basis. In these areas, 8 to 15% of the population carry the virus, and the most infections occur at birth or during childhood.

Hepatitis B virus is a 42 nm, double shelled deoxyribonucleic acid (DNA) virus.

Hepatitis B surface antigen (HBsAg) is found on the surface of the virus and on accompanying 22 nm spherical and tubular forms. The various serotypes (adr, adw, ayw, ayr) -of HBsAg provide useful epidemiologic markers. Anti-HBs, antibody to HBsAg, is responsible for long term immunity to anti HBC, antibody of the core antigen, develops in all patients with HBV infection and persists indefinitely. The Hepatitis, Be antigen (HbeAg) correlates with HBV replication and high infectivity. Anti-HBe develops in most HBV infections and correlates with lower infectivity.

Clinical signs and symptom of acute hepatitis B include various combinations of;

- Anorexia
- Malaise
- Nausea
- Vomiting
- Abdominal pain
- Jaundice
- Skin rashes
- Arthralgias, and
- Arthritis can also occur

Overall fatality rates for reported cases generally do not exceed 2%.

The incubation period of hepatitis B is long; 45 to 160 days (avg 60-120 days). A variety of ultimate out comes of this disease exit, including a carrier state, cirrhosis, acute hepatitis, and primary liver cancer.

MODES OF TRANSMISSION IN DENTISTRY

HBV is transmitted both percutaneously and non-percutaneously. Because dental treatment involves the use of small, sharp instruments, multiple opportunities exit for percutaneous wounds and staff. Non-percutaneous dental transmission includes the transfer of infections, such as saliva, blood and crevicular fluid.

Hepatitis B transmission in dental operations occur primarily in a horizontal mode among staff and patients. Studies have documented that this transmission is predominantly from patient to health care provider and less often from health provider to patient. Vertical transmission is also possible as when an infected dentist transmits hepatitis B perinatally. For this reason, it is now recommended that all pregnant women be screened for HBV infection during an early prenatal visit. If the mother is a hepatitis B carrier, the newborn must receive hepatitis B immune globulin (HBIG)-and hepatitis B-vaccine within a days of birth to avert development of infection.

FREQUENCY OF INFECTION

Patient population groups having a significantly increased prevalence of hepatitis B infection and, hence increased prevalence of the carrier state are, much larger. Most of these patients are unaware of their increased prevalence of hepatitis infection. An estimated 300,000 persons are infected with HBV every year. One quarter become ill with Jaundice, more than 10,000 patients require hospitalization and an average of 250 patients die of fulminant disease each year. Between 6 and 10% of young adults with HBV infection become carriers. The United states currently provides an estimated pool of l-million hepatitis B infected carriers. Chronic active hepatitis develops in over 25% of carriers and often progresses to cirrhosis. Furthermore, HBV carrier have a 12-300 times higher risk of developing primary liver cancer than the general population.

The majority of infections are subclinical jaundice is considered to be the most believed sign of hepatitis, but it is rarely evident. Depending on the route of transmission, virulence of the inoculum, and host resistant factors, as few as 1 in 30 or as many as 1 in 2 patients may actually develop jaundice. This approximately 80% of all hepatitis B infections are undiagnosed.

Researchers have demonstrated patient that medical histories are unreliable in identifying exposure to HBV infection. Regardless of the medical history, all patients should be regarded as potential HBV carriers. A carrier is defined as a person who is HBsAg positive on at least to occasions 6 months apart. Carriers develop very little anti-HBs and thus remain HBsAg positive. Although the degree of infectivity is best correlated with HBcAg positivity, any person positive or HBsAg is potentially infectious.

The likelihood of developing the carrier state varies inversely with the age at which infection occurs. During the perinatal period, HBV transmitted from HBeAg- positive mothers results in HBV carriage in upto 90% of infected infants, whereas 6% to 10% of acutely infected adults become carriers.

The hepatitis B carrier state develops more commonly by means of asymptomatic subclinical HBV infection versus acute infection. Additionally, carriers developing an asymptomatic subclinical infection are more likely to be HBeAg positive, indicating that they are in a more infectious contagious state and therefore more liable to transmit the disease.

Prevention of Transmission through Immunoprophylaxis

Active and Passive Immunity

- Active immunity occurs by stimulation of an individuals own immune response. Protection is provided only after a latent period; however, long term immunity is provided. Example of active immunization are actual acquisition of the disease (either subclinically or acutely) and vaccination.
- Passive immunity occurs by transferring performed antibodies from an actively immunized host to a person in need of immunity. The protection provided is transitory and onset is immediate.

Example of passive immunization include the injection of immune globulin IG or HBIG.

IG primarily provides protection against hepatitis A virus infection and is inexpensive. Passive immunoprophylaxis through injection of HBIG gives protection against HBV infection for about 2 months and is quite expensive.

Passive immunization may be used only if the dentist or staff member is aware of an exposure to HBV and if immediate action is taken but this is rare cases. Thus active, pre incident immunity is preferable. Active immunity can be conferred either through acute infection, subclinical disease, or hepatitis B vaccination.

Hepatitis B Vaccine

Plasma derived vaccine – Clinical tests of the plasma derived hepatitis B vaccine;

i. Hepatavax B began in 1975 and the licensed vaccine was introduced in the United states in 1982. The vaccine is given in 3 separate 20 ug intramuscular injections. The first two doses 1 month apart and the 3rd dose at 6 months (0, 1 and 6 months). Approximately 96% of young healthy adults seroconvert following the completion of vaccine series; achieve a protective level of antibodies to HBsAg (anti HBs) and are protected against the development of active hepatitis B, asymptomatic hepatitis B-infection, and the carrier state.

ii. Recombinant DNA vaccines: -Advances in vaccine development continued and Recombivax HB came into market in United state in 1987. Its an alternative to plasma derived vaccine. Recombivax HB is produced in cultures of Saccharomyces cerevisiae (common bakers yeast) into which a plasmid containing the gene for HBsAg has been inserted. HBsAg is subsequently harvested from the yeast cells. Administered vaccine is designed to contain 10 ug of HBsAg protein (0, 1 and 6 months).

iii. Another Recombinant DNA Vaccine: Engerix B was produced in Belgium and licensed for use in United states in 1989.

The two recombinant vaccines differ in their production process. Differences include use of, thiocyanate in Recombivax-HB production for conversion and folding of antigen, the use of an *in situ* formed alum adjunct may promote slow release of the antigen, formation treatment assists in microbial kill of extraneous contaminants and possibly antigen stabilization.

The amount of antigen per milliliter also differs between the recombinant vaccines.

10 mg/ml dose of HBsAg in Recombivax HB

20 mg/ml dose of HBsAg in Hepatavax-B

20 mg/ml dose of HBsAg in Engerix-B

Note: Hepatitis B virus has been shown to be killed or in activated by commonly used methods of sterilization and disinfection, including the steam autoclave and 10 minute exposure to 1:100 diluted bleach, 1:16 diluted phenolic glutaraldehyde, 75 parts/million iodophor and 70% isopropyl alcohol.

AIDS/HIV INFECTION

Acquired immune deficiency syndrome, termed AIDS, is the last stage of a debilitating, eventually fatal human disease. AIDS may develop in 1.5 to 11 or more years after an initial infection with the human immunodeficiency virus—HIV. HIV-1 is the most predominant type, HIV-2 is a type found in some West African emigrants. HIV is relatively fragile RNA retrovirus that is easily destroyed in the dry state in 1 to 2 minutes by most disinfectants.

HIV Epidemiology and Transmission

Since its recognition in 1981, HIV has infected an estimated 2 million people in the United States and produced AIDS in over 200,000 persons by 1992.

HIV is transmitted mainly by blood, blood-contaminated body fluids, semen, and Vaginal fluids. High risk groups are, having multiple sex-partners of same or opposite sex; having a sexual partner that is high risk or infected; intravenous drug abuse, hemophiliac treatment, blood transfusion and infants born to an infected parent. Casual, non-sexual contact, including social kissing and sharing towels or food among family members in a household with an AIDS victim, has not transmitted the infection.

Progression of HIV Infection into AIDS

In simple terms, after a prolonged quite state of 1.5 to possibly 12 years after infection, the AIDS virus begins to destroy cells that control the normal immunity of the body against infections and tumors. At that time the body becomes more and more vulnerable to many common viruses and microbe found in our normal environment. Commonly harmless parasites and fungi are then able to cause severe and often fatal pneumonia or cerebral infections.

One of the most important properties of the virus is its ability to convert its RNA to a, double stranded DNA, identical to the genetic material of the human where it establishes infection. This is accomplished by its reverse transcriptase enzyme system. In the first step, HIV like most other viruses, has to attach to target cell in which it replicates. The predominant target cell for HIV is CD4 (the surface attachment sites are termed "category designation four glycoprotein antigen) bearing T helper cell which plays a key role in immune regulation. In addition to CD4 cell, macrophages, dendritic, cells and Langerhan cells of the skin facilitate viral attachment and its replication. The virus outer glycoprotein gp 120 locks into the CD4 receptor on the target cell there by initiating the first step in virus replication namely, attachment.

Virus can also replicate in the cells of the central nervous system such as "microglial cells" which do not have CD4 receptors. The virus entry the glial cells through a non-CD4 receptor, which has now been identified as "galactosyl ceramide". In addition to these, a number of other co-receptors have been postulated, and "fusin" is one such co-receptors. It is believed that there will be 300 such co-receptors which work in conjunction with the major receptors. After attachment of virus, and entry of viral core into the target cell, the viral RNA is converted to DNA and integrated into the host genome. The implications of this integration is, once a person is infected, he is going to stay infected for life. Persons who are infected have a long incubation period ranging from 5-15 years during which the virus replicates at a very low rate.

After remaining latent during the prolonged incubation period in infected helper lymphocyte cells, the HIV commences to replicate. The lymphocytes die, releasing virus into the blood and thus the number of essential helper lymphocytes are drastically reduced. When helper cell counts fall to counts below $200/mm^3$, in the blood, many different opportunistic infections and tumors appears.

Symptoms and Oral Manifestations

- With in 3 months of the infection, temporary flu-like symptoms of pharyngitis, myalgia, fatigue, fever or diarrhea may occur when antibody to HIV becomes detectable.
- After prolonged incubation of about 1.5 to 12 years, any of several early signs of AIDS may be detected by the dentist, signaling gradual failure of immune system.

  Easily detected during examination are one or two cervical lymph nodes, especially below the mandible that persists more than 3 months. Nodes may be attached, painless (or) mobile, painful, infected.
- Undifferentiated non-Hodgkin's lymphoma cancers may arise in lymph nodes or may appear in the mandible as well as in CNS, eyes, bone marrow and other vital organs.
- Oral candidiasis is often seen with easily dislodged white curd like patches scattered over the tongue. In AIDS such infection may not easily respond to treatment and often recurs, developing into atrophic candidiasis, or cheilitis.
- Painful herpes stomatitis is also common.
- Red, brownish to purple blotches that persist on the oral mucosa and skin of the individual typify a sarcoma of the capillaries, termed "Kaposis sarcoma". (Often found on oral tissues of male homosexuals).
- A persistent, severe, recurrent gingivitis and periodontitis typical of AIDS is a common finding that brings patient for dental care.
- Early systemic signs of illness progressing toward AIDS are marked by weight loss of upto 50 pounds within a few months and chronic fever and night seats that persists for 3 months.

Serology of HIV Infection

HIV infection is detected by blood tests, such as;

1. ELISA-Enzyme linked immunosorbent assay.
2. Western blot
3. Fluorescent antibody tests that detect antibodies formed against the virus.

Tests for HIV-antibody are often positive within 3 months after infection; most are positive by 6 months; 1% take upto 12 months to become positive.

One criterion for starting "Zidovudine" therapy is a T4 helper cell count below 500/ mm^3 of blood.

There are 2 main approaches in diagnosis of HIV infection.

- Direct - PCR - Polymerase chain reaction
- Indirect - ELISA
- Western Blot

Direct approach seeks information on the presence of the virus itself by classical isolation method and identifying the presence of virus specific genes by molecular biology technique. This is quite expensive, and enquire highly trained personnels.

ELISA Test: First to be introduced screening for confirmation of HIV antibody.

In ELISA, which is in done a 96-well polystyrene microtitreplate, the plates are coated with HIV-specific antigen and allowed to react with patients serum. If the serum has antibody it will react with antigen and form an immune complex. The unbound antibody is removed by a washing procedure. The bound HIV, specific antibody is then incubated with an anti-human IgG antibody made in other species (e.g. goat, sheap) and coupled to enzyme such as "conjugate". After washing the excess conjugate again by washing step, the presence of enzyme is detected by allowing it to react with a substrate and indicator system. Finally the samples containing HIV antibody will show color the intensity of which will depend upon the amount of antibody present; samples containing no antibody will show faint color only. The intensity of color due to each sample is quontitated by an ELISA reader which is a modified spectrometer.

When ELISA is done, a battery of controls are included with each run of patients samples. These are positive controls, negative controls and cut off controls for the calculation of cut-off point which is the reading above which a sample is considered as positive and below which it is negative.

HIV Data Related to Infection Control

1. Unlike Hepatitis B virus, HIV has usually been found in very low levels in blood of infected persons.
2. HIV was detected in only 28 of 50 samples of blood from -infected persons. In saliva from the infected person, HIV was detectable in only 1 of 83 samples.
3. In dried infected blood, 99% of HIV has been found by CDC investigators to be inactive in 90 minutes. When kept wet the virus may survive for 2 or more days.

   Caution is required with containers of used needles in which the virus may remain wet.
4. HIV is killed by all methods of sterilization. When used properly all disinfectants except some quarternary ammonium compound are said to inactivate HIV in less than 2 minutes.
5. HIV has been transmitted by blood contaminated fluids that have been heavily scattered or splashed. Aerosols those produced during dental treatments have not been found to transmit Hepatitis B or HIV infection.
6. Barriers have proven successful in protecting dental personnel in hospital dentistry and in all other dental clinics against HIV.

PERSONAL BARRIER PROTECTION

It is always better to prevent contamination than to rely totally on our body's resistance to fight off disease agents after contamination.

When exposure is likely the best way to prevent contamination is to use protective barriers such as gloves, masks, protective eye wear and protective clothing.

Gloves: Gloves not only protect dental team members from direct contact with micro-organisms in patients months and on contaminated surfaces, but they also protect patients from micro-organisms on the hands of the dental team.

Protection of the Dental Team

Although intact skin is an excellent barrier to disease agents, a small or even invisible cuts can serve as an route of entry of micro-organisms.

Another protective value of wearing gloves in the office protection against contact with chemicals that may irritate the skin such as cleaners, disinfectants, sterilants, X-ray developing solutions and some dental materials. Also, heat resistant gloves protect against burns when heat processing instruments are handled.

Protection of Patients

Micro-organisms are present on just about every surface in the office that has not been cleaned and disinfected.

Thus without gloved hands become contaminated with micro-organisms on touching just about any environmental surface and from direct contact with fluids or surfaces in patients mouth. If these contaminating micro-organisms are not removed by hand washing may be covered or with gloves they up transmitted to a patient.

USES AND TYPES OF GLOVES

Types

Patient Care Gloves

- Sterile latex surgeon's gloves
- Sterile latex examination gloves
- Sterile vinylgloves
- Non-sterile latex examination gloves
- Non-sterile vinyl examination gloves
- Powderless gloves
- Hypoallergic gloves
- Flavored gloves

Utility Gloves

- Heavy latex gloves
- Heavy/thin nitrile gloves
- Thin copolymer gloves
- Thin plastic gloves

Other Gloves

- Heat resistant gloves
- Dermal gloves

Uses

- Gloves used for patient care are not to be reused on a subsequent patient. Also, do not wash patient care gloves with any detergent or chemical, it weakens the glove material.
- If you leave chairside during patient care. It is best to remove gloves first and wore a fresh pair on returning to chairside.
- An alternative to changing gloves in these situations is to use inexpensive copolymer or plastic gloves or a sheet of plastic wrap over the patient care gloves.
- Torn or punctured gloves must be removed as soon as possible, followed by immediate hand washing and replacing with fresh gloves.
- Sterile latex/vinyl gloves are used during surgical procedures.
- Operatory cleans up and instrument processing during operatory clean up and handling instruments, in latex/vinyl patient care/thin copolymer/plastic gloves are used.
- Use utility gloves of nitrile or heavy latex when using chemicals and disinfectants.
- Heat resistant gloves for handling not items.

Limitations of Gloves

Although gloves provide a high level of protection against direct contact with infectious agents through toughing, they offer little protection against injuries with sharp objects such as instruments, needles and scalpel blades. Thus contaminated stays must be handled with care.

- Do not use gloves that are torn
- Do not reuse utility gloves if they are peeling, cracking, discolored, torn, punctured.

Handwashing

Hands have long been known to be one of the most important sources of micro-organisms in disease spread. Hand washing is an important type of personnel hygiene for every one.

There are 2 types of microbial flora on the hands, the resident and the transient skin flora.

Resident flora consists of those micro-organism that colonize the skin and become permanent residents. They are always there, they can never be removed totally but their numbers can be reduced.

Transient skin flora micro-organisms of this flora contaminate the hands during the touching of or other exposure to contaminated surfaces. They do not usually colonize and survive on hands for long time, they come and go -> transient.

Instructions for Handwashing

At the beginning of the routine treatment period, remove watches jwelery and rings and then wash hands with a suitable cleaner. Leather hands for at least 10 seconds, rubbing all surfaces and rinse. Use clean brush to scrub under and around nails. Repeat at least once to remove all soil.

Common antimicrobial agent in hand washing products include chlorhexidine digluconate, povidone iodine, parachlormetaxylenol, and triclosan.

Masks

Masks were developed originally to reduce the chances of postoperative infections in patient caused by micro-organisms in the respiratory tract of the surgeons.

In dentistry masks do protect mucous membranes of the nose and mouth of dental team from contact with sprays and splashes of oral fluids from the patient. The mask should be changed with every patient because its outer urface is contaminated with droplets form sprays of oral fluids from the previous patient or from touching the mask with saliva coated fingers.

Face masks are composed of synthetic material that serves to filter out 95% to 99.9% of 2-3 mm size particles that directly contact the mask.

Limitations of Face Masks

Face masks do not provide a perfect seal around their edges and inhaled and exhaled air that is not filtered does pass through these sites. So it is important to select the mask which fits the face well to minimize passage of unfiltered air. When a mask becomes wet from moist exhaled air, the resistance to airflow through the mask increases, causing more unfiltered air to pass by the edges. Thus wet masks should be replaced for every 20-minutes.

Protective Eyewear

A variety of disease agents may cause harmful infection of the eyes or enter the associated mucous membranes and cause systemic infections.

Example: Herpes virus

Hepatitis B

Eye wear also can protect against damage eye form ultraviolet irradiation and from splashes of chemicals used at chairside. Patients also should be offered eye protection during care.

Uses: Protective eye wear should be worn when ever there is chance for contamination of the eyes with aerosols, sprays, or splashes of body fluids and during grinding, polishing, procedure.

- Front and side protected glasses should be used.
- Some protective eye glasses have replaceable lenses if scratching occurs, have antifogging properties and are autoclavable.

Protective Clothing

Potentially infectious micro-organisms may be present in the aerosols, sprays, splashes and droplets from the oral fluids of patients. These not only contaminate unprotected eyes and mucous membrane of the mouth and nose, but also contaminate other body sites of the dental team, including forearms and chest area. Our protective clothing can protect against this contamination, which otherwise may lead to infection through non intact skin or at least spread of contamination from office to home.

HAZARDOUS WASTE MANAGEMENT

The Environmental Protection Agency (EPA) describes solid waste as discard solid, liquid, semisolid and contained gaseous material, among other materials. It defines medical waste as a subset of solid waste, as follows:

Any solid waste which is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto or in the production or testing of biologicals.

Biomedical waste means any waste which is generated or has been used in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, in the production or testing of biologicals, or which may contain infectious agents and may pose a substantial threatto health. Biomedical waste includes biohazardous waste and medical solid waste.

Biohazardous Waste Means any of the Following

1. Lab waste - which may contain infectious agents and may pose substantial threat to life.
2. Recognizable fluid blood elements and regulated body fluids.
3. Any sharp instruments, such as needles, blades, slides.
4. Contaminated animal carcasses.
5. Any specimen sent to lab for microbiological analysis.
6. Medical solid waste include;

Bandages, dressings, surgical gloves, specimen containers etc.

ASEPTIC TECHNIQUES

Aspetic techniques prevent or reduce the spread of micro-organisms from one site to another, such as from patient to dental team, from patient to operatory surfaces or from one operatory surfaces to another. During each appointment:

1. Directly touch only what has to be touched
   – i.e. touch a few surfaces or possible
2. Remember, whatever is touched is contaminated
3. Use one of the following to control contamination:
   a. Clean and sterilize it
   b. Use a disposable device and discard it after use’
   c. Protect it with disposable, single use covers
   d Scrub and disinfect it as well as possible

With treatment soiled gloves, avoid unnecessary contact with all switches, drawers, dispenser or surfaces on the unit that need not to be touched.

- Use single use plastic bags on control unit and chairback, foil or plastic baggies on lamp handles, and use foot controls.

Operatory Asepsis

Protection of operatory surface: Principles.

- Operatory surfaces that will be repeatedly touched or soiled are best protected with disposable covers that can be discarded after each treatment. Changing covers eliminates cleaning and disinfecting the surface, save time, effort and expense and can be more protective.

- For dental unit trays paper, or plastic film or aluminum film or surgical pack travels should cover the entire tray.
- Use plastic or a small sheet of foil wrap on lamp handles.
- In expensive large "clear plastic bags" are used in dental office to cover chair back, control unit and hose support.
- After each appointment, discard and replace these bags and covers.

Preparation of Semicritical (Attached to Unit for re-use) and Non-critical Items (Supporting or Environmental)

Critical Items

Instruments that contact cut tissues or penetrate tissues are considered to be critical items that require thorough cleaning and sterilization for re use.

Semicritical Items

A number of attached items to the dental unit that re used intraorally, or are handled/ touched interchangeably with mucosal by gloved hands coated with blood and saliva.

Example, Air water syringe, suction tips, prophangle and hand pieces. Semicritical items must be removed for cleaning and sterilization unless they are disposable and should not be disinfected.

Noncritical Items

Are environmental surfaces such as chairs, benches, floors, walls and supporting equipment of the dental unit that are not touched during treatments.

- Contaminated non-critical items require cleaning and disinfection.

Disinfection: At least 2 procedure.

1. Initial step involves vigorous scrubbing of the surfaces to be disinfected and wiping them clean.
2. The second step involves cutting the surface with a disinfectant and leaving it wet for the time prescribed by manufacturer.

For cleaning and disinfecting metal surfaces "nitrile latex utility gloves" are preferred.

Disinfectants Preferred

Are those that inactive polio/coxsackievirus similar to Hepatitis B in resistance.

Disinfectants must be active against "Mycobacterium Species", common respiratory viruses, common bacterial hospital pathogens. All such disinfectants readily inactive HIV in 1 to 2 minutes.

- Glutaraldehyde is toxic
- Preferred by EPA,
  1. 1:10 to 1:100 dilutions of 5% hypochlorite in H_2O (house hold bleach).
  2. Plain dilute iodine solutions.
  3. Iodophor disinfectants containing phosphoric acid.
  4. Water based synthetic complex phenolic derivatives containing 9% O-Phenyl-phenol, 1% O-benzyl-P-chlorophenol diluted 1 ounce to 1 quart of H_2O to give 0.3% of final solution.
  5. 79% ethyl alcohol spray.

Time to Disinfect – 5-10 minutes.

Step by Step Preparation of Dental Chair, Dental Unit and Instruments

Note: Do not disinfect surfaces and items covered with plastic drapes after each treatment unless it is torn.

1. With hands still gloved after the last treatment, remove and invert chairback cover, discard cotton rolls and other disposable mats into the cover, discard the cover into operatory drashbin. Remove and discard glove aseptically.
2. Wash hands with antiseptic hand soap, rinse and dry. Place there proper towels on the dental seat for later placement of air/H_2O syringe and end of suction hoses. Put on nitrile latex utility gloves.
3. With the used suction tip, clean saliva and debris from the cuspid trap. Discard the suction tip into drash bin.
4. Remove the needle from syringe cover it with sheath and dispose in a sharp container.
5. Return the air/H_2O syringe tip, hand piece and pass of instruments to the clean up area.
6. Before handling disinfectant dispensing bottles, wash gloves with antiseptic.
7. Spray any used bottles, containers, tubes, unused burs with disinfectant and wipe with paper towel.
8. Remove the air/H_2O syringe and suction hoses form hanger. Remove the plastic covers from hose ends and discard. Lay air/H_2O syringe and suction hose ends on the paper tanks previously placed on dental chair.
9. Insert, remove and discard plastic drapes from the control unit, remove and discard protective covers from lamp handles.
10. For any controls and switches that were not covered, wet a pipe towel with disinfectant and wipe lamp switch and controls. (Do not spray control switches).
11. Use a second towel wet with disinfectant to rewet these items and leave them wet. (because paper towels neutralizes iodine disinfectants).
12. Spray the outside and inside of cuspid or with disinfectant.
13. Spray any contaminated surroundings and wipe it with paper towel.
14. Wash utility gloves still on hands with strong antiseptic hand scrub and dry them with paper towels, and discard the towels. Utility gloves can be disinfected. Nitrile latex can be autoclaved.

To prepare the unit for the next patient gloves need not be worn if only clean surfaces that have been protected with covers are touched.

1. Pull a large clear plastic bag cover the dental control unit from the front and check excess under the unit. Split the bag up one side to cover mobile delivery system.
2. Pull another bag down over the chair back and also cover chair arms.
3. Install suction and air/water syringe tips. Place a slender bag over each tip, pushing the tip through the end of the bag.
4. Install sterilized hand pieces.
5. Arrange the materials and instruments.
6. Seat the patient and put on a clean most, eye wear and glasses.

Principle and Procedures for Handling and Cleaning Instruments after Treatment

- Protective utility gloves made of nitrile latex are the most puncture resistant should be used for handling sharp instruments.
- Instrument containers are used as specified by OSHA regulations, place contaminated reusable sharp into container immediately after use which is now punctured and leak proof.
- A disinfectant holding solution for soaking used instruments should contain a detergent, be economical, not corrode

instruments, not given off toxic aldehyde vapors and have 10 minutes well-verified anti-microbial claims against TB and polio/cocksackie virus.
- Use suitable brush along with disinfectant.
- Dry it with paper towels.

Ultrasonic Cleansers

Is the safest and most efficient way to clean sharp instruments after it has been rinsed.

It is 9 times effective than hand cleansing.

Operating Precautions

1. Operate the tank one half to 3/4th full of cleansing solution at all times.
2. Use only cleaning solutions recommended by manufactures change solutions as directed.
3. Operate the ultrasonic cleaners for 5 minutes or longer's directed.
4. Coatings such as plaster, wax, cement and impression material can be removed with an appropriate solvent cleanser placed in beaker in the ultrasonic device.
5. Verify the performance monthly – by foil test.

Foil Test

- Add solution to tank and operate for 5 minutes to expel dissolved gases.
- Measure depth and length of the solution.
- From roll of aluminum foil, cut 1 inch more than depth of solution and 1" less than length and handle foil like certain without touching the bottom at the centre.
- Operate it for 20 seconds.
- Every ½ square inch of the foil should show small visible indentations if the device functions properly.

STERILIZATION

It is a process by which an article, surface or medium free from all micro-organisms either in the vegetative or spore state.

Disinfection: A less lethal process than sterlization, it eliminates virtually all pathogenic vegetative micro-organisms but not necessarily all microbial forms (spores).

Accepted Methods of Sterilization

There are 4 accepted methods;
1. Steam pressure sterilization (Autoclave)
2. Chemical vapor pressure sterilization (Chemiclave)
3. Dry heat sterilization (dry calve)
4. Ethylene oxide sterilization

Selection of Sterilization Methods and Equipment

It is best to evaluate office needs and examine various sterilizer capabilities, then carefully select one or two methods of sterilization.
- Stainless steel instruments and mirrors used for operative endodontic can be sterilized by any accepted method.
- Hand pieces can be autoclaved.
- Burs can be sterilized in dry heat or chemic lave.
- Metal impression trays can be sterilized by any method, but dry heat above 3450 F may remove soldered handles.
- Orthopliers of high quality stainless steel will resist corrosion in autoclave.
- Excellent penetration of packages.
- Sterilizing is verifiable.

Disadvantages

- Items sensitive to the elevated temperature cannot be autoclaved.

- Autoclaving tends to rust carbon steel instruments and burs.
- Steam appears to corrode the steel neck and shank portions of some diamond instruments and carbide burs.

Sterilization of Burs in Autoclaves

To avoid corrosion or rust, burs are most simply sterilized in a dry heat oven or ethylene oxide gas sterilizer. For autoclave sterilizing, burs can be protected by keeping them submerged in small amount of 2% sodium nitrite solutions. Add 20 g of nitrite to 1 lit of H_2O.

(Nitrites are commonly added to preserve processed meat, example: hot dogs).

CHEMICAL VAPOR STERILIZATION (CHEMICLAVING)

In 1940 the work of Hollenback and Harvey developed chemical vapor sterilization. The principle of chemiclave sterilization is that although some H_2O is necessary to catalyze the destruction of all micro-organisms in short time, H_2O saturation is not necessary.

- Chemiclaving uses solutions containing specific amounts of various alcohol, acetone, ketone and formaldehyde and H_2O is below 15%.
- When the chemiclave heated to 132°C (270°F) and pressurized to 20 lbs/sq inch sterilization occurs in 20 minutes.
- Careful arrangement of the load.
- Vapor is allowed to circulate freely within chemiclave.
- A fresh mixture of solution is used for each cycle i.e. solution is not recirculated.
- Adequate ventilation should be provided when it is used (odor).

Advantages

- Not corrosive to metals
- Relatively quick
- Load comes out dry
- Sterilization is verifiable

Disadvantages

- Vapour odor may be offensive, require increased ventilation
- Heat sensitive mostly can be destroyed
- Towels and heavy wrap clothing for instruments may not be penetrated
- Special chemicals must be purchased

DRY HEAT STERILIZATION

Prolonged Dry Heat

Dry heat kills the micro-organisms primarily through an oxidation process. Protein co-agulation also take place, depending on the water content of the protein and the temperature of the sterilization.

Dry heat is very slow to penetrate instrument loads. It sterilizes at 160^o in 30 minutes, but instrument loads may take 30-90 minutes to reach the temperature. To provide margin of the safety instrument must be sterilized at 160^o C for 2 hours. The hot air must be allowed to circuit freely within the sterilizer.

Note: Scrap amalgam keep out of any device, because once contaminated with mercury or amalgam, it continues to produce mercury vapour.

Advantages

- Large load capability
- Complete corrosion protection for dry instruments
- Low initial cost of equipment
- Sterilization is verifiable

Disadvantages

- Slow instruments turn-around because of poor heat exchange

- Sterilization cycles not as exact as in moist heat sterilization
- Dry heat sterilizer must be calibrated and monitored
- If sterilizer temperature is too high, instruments may be damaged

Rapid Dry Heat Sterilization

A rapid high temperature process that uses a forced draft oven (a mechanical convection oven that circulates air with a fan) and it reduces total sterilization time to 6 minutes for unwrapped and 12 minutes for wrapped instruments. They operate at 370°F to 375°F. Chamfer size is limited.

Advantages of Dry Heat

- Carbon steel instruments and burs do not resist.

Disadvantages

High temperature may damage more heat sensitive items.

Intense Dry Heat Sterilization

Chairside sterilization of endo files can be accomplished by using glass bead sterilizer or salt sterilizer.

At the temperature of 220°C (428°F), contaminated endo instruments requiring 15 seconds to be sterilized. They need extensive warm up times.

Advantages

- Small and convenient to use
- Serves as emergency backup to other methods of sterilization

Disadvantages

- Small instruments can be sterilized
- Sterilization is non verifiable

ETHYLENE OXIDE GAS STERILIZATION (ETO)

Ethylene oxide was first sued as a sterilizing agent in the late 1940's by Army Chemical Corps. Since then it gained popularity in hospital sterilization. The extreme penetrability of the ETO molecule, together with its effectiveness at low temperature (70 to 140°F), make it ideal or sterilizing heat sensitive materials.

ETO kills micro-organisms by reacting chemically with nucleic acids. The basic reaction is alkalation of hydroxyl groups.

Note: ETO is thought to be potentially mutagenic and carcinogenic.

Advantages

- Operates effectively at low temperature
- Gas is extremely penetrative
- Can be used to sterilize sensitive equipment such as dental handpiece
- Sterilization is verifiable

Disadvantages

- Gas is potentially mutagenic and carcinogenic
- Requires an aeration chamber
- Cycle time lasts many hours (often overnight)

BOILING WATER

Boiling water does not kill spores and cannot sterilize instruments. Boiling is method of high level disinfection that is useful when actual sterilization cannot be achieved. A well cleaned items must be completely submerged and allowed to boil at 98 to 100°C (at sea level) for 10 minutes. Great care must be exercised that instruments do not boil dry. Simple steaming is not reliable. Pressure cooking similar to steam autoclaving is preferred at high altitudes.

Handpiece Sterilization

- Autoclave sterilization of handpieces is one of the most rapid methods.
- Handpiece with metal bearing turbine, scrub the metal bearing with under running water and detergent, bag the hand piece and autoclave them.
- Handpiece with "lube free" ceramic bearing turbine, follow manufacturer's directions for cleaning handpieces with lubrication free ceramic bearing turbine. Avoid using chemicals that will damage internal parts.
- Handpiece with ceramic bearing can be sterilized in chemical vapor sterilization.
- ETO – Ethylene oxide gas is the most gentle method of sterilizing handpiece.

GLUTARALDEHYDE SOLUTIONS

The use of glutaraldehyde prepares for chemical sterilization of heat sensitive equipment has become a wide spread practice. Glutaraldehyde kills the micro-organisms by altering essential protein components. In acidic state Glutaraldehyde is stable but not sporicidal when glutaraldehyde solution is "activated" by a suitable alkaline buffer, full antimicrobial activity occurs.
- They usually have a shelf life of 14 days
- Sterilizing may take 6-10 hours depending on what product is used.

Advantages

- Sterilizes heat sensitive equipment
- Is relatively non-corrosive and non-toxic.

Disadvantages

- Requires long immersion time
- Has some odor, which may be objectable
- Sterilization is non verifiable (strips monitor)
- It is irritating to mucous membrane (eyes)

Other solutions commonly used:
1. NaOCl – house hold bleach (5%)
2. Iodophors
3. Alcohols

Monitoring Sterilization

Two methods are commonly used to monitor in office sterilization;
1. Process indicators
2. Biologic indicators

Both are necessary parts of infection control.

Process Indicator

Are usually strips, tape or paper products marked with special ink that changes color on exposure to heat, steam, chemical vapour or ETO. The ink changes color when items being processed have been subjected to sterilizing conditions, but it does not monitor how long such conditions were present.

The main role in infection control is to prevent accidental use of materials that have not been sterilized.
- A color change in process indicator does not ensure that proper sterilization has been achieved.

Biologic Indicators

Are usually preparations of non-pathologic bacterial spores that serve as a challenge to a specific method of sterilization. If a sterilization method destroys spore forms that are highly resistant to that method, it is logical that all other life forms have also been destroyed. The bacterial spores are usually attached to paper strip within a biologically protected pocket. Spore packet is placed between instruments after sterilization spore strip is cultured for specific time, lack of culture growth indicates sterility. (Sterilization is properly)

Gutta Percha Sterilization

Immersing gutta percha concentrations in 5.25% sodium hypochlorite solution for 1 minute kills vegetative micro-organisms and spore.

New Methods of Sterilization

Various new methods of sterilization are under investigation and development.

- The "Microwave oven" has major limitations for sterilizing metal items without damaging the machine and reach in all side of instruments.
- Use of "Peroxide vapor sterilization" is under development.
- Ultraviolet irradiation may be useful for sanitizing room air to control T.B. Bacteria.

Infection Control Procedures for Handling and Transporting to a Remote Laboratory Items for a Non-Aqueous Polymer Based Rubber Impression Technique and Any Associated Registration

Infectious control procedures regarding the non aqueous rubber based impression and any associated registration are as follows:

1. Before the patient appointment, prepare one or more industrially clean, strong, clear, heat sealable, biohazard-labeled plastic bags of appropriate size, one for containing the scheduled impression and a separate one for any associated interocclusal registration. Place each bag into an open canister of suitable size so that the bags open and extends above the rim of the supporting canister, allowing a slight folding downward and outward of the bags open edge. This helps to keep it open and also prevents contamination of the bags outer surface during insertion of the item.
2. Remove the impression/interocclusal registration from the mouth with the gloves, remove any attached debris and rinse the item well with running tap water for 15 seconds to remove saliva and blood.
3. Now remove the gloves (because they are contaminated) with clean hands, close the bag while touching only the bag's clean outer surface and heat seal it.
4. Tape the prescription to the bag.
5. Attach a note that items in the bag were debrided and rinsed but not disinfected. Place the bag into suitable box and send to remote lab. Lab person will proceed with disinfecting the items sent, whether patient has an infection or not.
6. If the non-aqueous rubber impression is to be poured in the dental office, the impression must be disinfected before the cast is formed. (See infection control for handling impressions and associated registration in the on site lab).

Infection Control, Procedure for Handling and Transporting to a Remote Lab Items From an Aqueous Impression Material Technique [Using Alginate (Irreversible Hydrocolloid) Or Reversible Hydrocolloid] and any Associated Registration

If the aqueous impression is to be poured in-office and the resultant cast and associated items transported to a remote lab, infection control procedure are as follows:

1. Thoroughly rinse the impression under tap water 15 seconds to remove any saliva or blood.
2. Disinfect the impression by submerging it for 10 minutes in a fresh 0.5% solution of commercial bleach (add 1 part of 5.25% sodium hypochlorite to 9 parts of H_2O).
   - Do not exceed 30 minutes submersion time for reversible hydrocolloid.
3. With clean hands, thoroughly rinse the disinfected impression under tap water

to avoid prolonged exposure to the disinfectant and because any residual disinfectant can adversely affect surface hardness of the stone cast.

4. Shake off excess water from the impression and pour the cast immediately.

   One reversible hydrocolloid manufacturer's offers two alternatives to immediate pouring of the impression after disinfection.

   Option I, submerge the impression into a 2% potassium sulfate solution for 20 minutes, and then remove, shake off excess and pour the impression.

   Option 2, place the impression into a humidor (for upto 4 hours with no temperature change), remove, submerge into 2% potassium sulfate solution, and pour the impression (1 capful of crystals to 1 pint of H_2O).
5. The cast from a disinfected impression does not need disinfecting.
6. Carefully pack it, leave a written note that impression and associated registration were disinfected and that the cast should not be disinfected which might compromise accuracy.

Infection Control for Handling Impressions and associated in the On-site Lab

Lab personnel are required to wear clean gown disposable mask, protective eye wear and gloves.

1. All the incoming items to the lab must be properly labeled. With the gloved hands, disinfect impressions (associated registrations) by submerging for 10 minutes in 1:10 dilution (0.5%) of house liquid chlorine bleach (5.25% Na-hypochlorite) prepared freshly.
2. With gloved hands, spray articulators and any related equipment that have been contaminated, and which cannot be sterilized, with an alcohol since chlorine in the hpochlorite type disinfectant may damage the metal.
3. With clean hands, thoroughly rinse the impression under tap water (15 seconds to remove any residual disinfectant and follow manufacturer's direction for additional procedure).
4. All out going items must be properly cleaned and placed in leak proof bag.
5. Contaminated counter taps and work surfaces must be cleaned of debris and disinfected daily.

SUMMARY

From an infecting disease point of view, dentistry has never been safer than it is today for both patients and the dental team. This state of affairs has resulted from the establishment and practice of strict infection control in the office using the concept of universal precautions. Infection control consists of a series of procedures directed at reducing the number of microbes shared among people. An approach to the management of infection control involves identification of an office. Safety coordinate and total involvement of everyone in the office. The procedure of the infection control can be grouped into six major areas.

1. Hand washing and gloving provide protection to both patients and the dental team.
2. Protection against aerosols and spatter involves the use of pre procedure mouthrinse, rubber dam, saliva ejection, mask, protective eye wear and protective clothing.
3. Instrument polishing provides instruments that are safe for patient use.
4. Surface aspects
5. Management of sharps and other regulated wastes, and
6. Aseptic techniques.

20 Recent Concepts in Cavity Preparation

MINIMAL INTERVENTION DENTISTRY (MID)

Also called minimally invasive dentistry or preservative dentistry.

INTRODUCTION

- Mostly the cavity classification designed by G.V. Black had been followed.
- Carious lesions were treated by a surgical approach based on principle of extension for prevention. This was because of poor quality of material and lack of understanding of carious process.
- With the invent of rotary instrument. In 1950, this extension was further increased which weakers of excess tooth structure. – replacement dentistry.
- Recently it has been proposed that with fluorine ion its possible to remineralization early lesions. –therapeutic/biologic approach.
- Thus MID was introduced.

It embodies four principles:

a. Reduction in cariogenic bacteria in order to eliminate risk of further demineralization.
b. Demineralization of early lesions.
c. Minimum surgical intervention of caries lesion.
d. Repair rather that replacement of defective rest.

Potential for MID is dependent on following factors:

1. Demineralization cycle.
2. Adhesion in restorative dentistry
3. Bio-compatibility of restorative materials

Demineralization (biological approach)
This is ha DRC because tooth continuously loses and gains Ca and PO_4 ions depending on microenvironment.

At PH < 5.5 Subsurface enamel begins to demineralization. As pH increases remineralization occurs.

In the presence of fluoride, the remineralization stage forms fluorapetite rather than hydroxyapetite.

Advantages of Fluoride

1. Critical (pH 4.5 to 5.5) of Caries. The increase in pH and make it more resistant to caries.
2. Bacteriostatic
3. Modified surface energy of enamel so that plaque does not adhered to it.
4. F buffers pH of plaque on tooth surface.

Two elements of biologic approach are:

1. alteration of oral environment in order to decrease demineralization–decrease carbohydrate intake, educational, plaque control.
2. Application of agents such as chlorhexidine and topical fluoride.

Adhesion in Restorative Dentistry

Two types of adhesion chemical:

Micromechanical: By bevels and acid etch and DBA is composite, it will lead to shrinkage with times i.e. microleakage.

GIC: adhesion due to ion exchange.

- Poly acid from GIC attacks tooth surface decrease Ca and PO_4 ions which reprecipitate along with Ca, PO_4 and Al was decreased from the glass, forming a new material, which unites the two.
- Also adhesion takes place between acid carboxylate group and collagen.

Biomimetic restorative material

- Material should reproduce one or more natural phenomena within a biologic situation.
- Material should be biocompatible.
- No inflammatory response after placement, example: GIC.

Chemomechanical Caries Removal

- It involves selective removal of carious dentine.
- A solution that selectivity. Softens the carious dentine, thus facilitating its removal.
- This limits the removal of sound tooth structure the cutting of open dentine tubules, pulpal irritation and pain compared with conventional mechanical methods.

Principle

- Selective removal of carious dentine, avoiding painful and unnecessary removal of sound dentine.
- A CMCR reagent causes degradation of partially degraded collagen (infected) and helps in caries removal.

Material

- First commercial material available was caridex (National Patent Medical Products) in US in 1985.

Use

Involved intermittent application of preheated N-monochloro-DL-2-aminobutyric acid (GK-101E) to carious lesion. These material lead to disruption of collagen in carious dentine so that easy to remove.

Composition: Two solutions

Solution I: NaOCl

Solution II: glycine, aminobutyric acid, sodium chloride and sodium hydroxide (Solution are mixed first before use)

Reagent selectively removed carious dentine and left behind was rough surface which is best for restoration with composites/GIC.

Indications

- Deciduous teeth
- Dental phobics
- Medically compromised patients.

Advantages

- Decrease need for LA
- Conservation of sound, tooth structure
- Decrease risk of pulp exposure

Disadvantages

- Rotary or hand instrument may be required to remove tissue or any restoration material.
- Expensive, additional clinical time and bulky delivery system.
- Large volume of solution was required

In 1998, Medical team delivered a new system called cariosolution–gel forms

Solution I–NaOCl (0.5%)

Solution II
a. amino acids (glulanic, leucine, lysine)
b. gel subs–carboxy methylcellular to increase viscosity.
c. NaCl/NaOH
d. Saline solution
e. Colouring indication (Red).

Advantages Over Caridex

- There amino acids incorporated to improve interaction with degraded collagen.
- High viscosity
- No preheating or complex equipment required
- Increase viscosity enhances precision time
- Overall stability is increased

Indications

- for preservation of tooth structure
- removal of root/crevical caries
- management of coronal caries
- removal of caries from margins of crown and bridge abutments
- for tunnel preparation
- Dental phobic
- Deciduous teeth
- ART
- Medically compromised/handicapped

Clinical Procedure

Case selection: Initially buccal root caries/ occlusal caries with 1 to 2 mm of entry opening.

Instrumentations

Instrument with four handles and inter-changeable tip with diameter of 0.3-2 mm or with spoon excavator. (Curetting Action)

Cavity Preparation

Applying Gel within 20-30 mts of mixing apply gel and leave it for 30 seconds to degrade the diseased dentines. As caries is remove gel becomes clouded.

Cavity Assessment

1. Gel is no longer cloudy once removal is complete.
2. Frosted and irregular appearance of bond dentin.

Air Abrasion Technology

By Dr. Robert B. Black in 1945.

Principle

This technique utilizes the K.E. from the alumina particles traveling in a high velocity stream of air to remove the tooth structure thus also called as kinetic cavity preparation by Lord Kelvin.

Tooth Preparation

- Abrasive used is purified aluminium oxide particles or alpha-alumina.
- Particle size 20-50 um.
- Pressure used to propel the abrasive particles for caries removal at 4-5 atmosphere.
- Removes harder material faster than softer ones.
- This is because K.E. abrasive particles gets absorbed due to resiliency of the soft material.

Advantage: Safety removes without any harm to oral tissues.

Size of nozzle: 0.8 mm to 1.2 mm, depending on size of abrasive particles.

Distance of Nozzle from Tooth Surface

Width of cavity prepared depends on distance of nozzle from tooth surface.

When close to tooth–width of cutting path away width is 500 mm. When moved slightly away 1-2 mm width. Thus for smaller conservative cavity preparation to be restored by composite resin.

– to increase mechanical restoration of resin by increasing surface roughness distance 2 mm.
– For butt joint nozzle – 0.5 mm from tooth.

SEM Observation of Surface Shows

1. Rounded cavosurface margins and rounded internal line angles.
2. Microscopic roughness of enamel and dentine. These defects produce a mechanical bond with a strength equal to or greater than that achieved with acid etch.
3. Apparent closure of dentinal tubules as air abrasive continuous, dentinal tubules gel blocked thus less pain.

Uses

1. For surface preparation to receive resin restoration.
2. Pit and fissure sealants
3. Fissure caries
4. Composite repairs
5. Laminate repair.

Advantages

1. Lack of vibration decrease heat production pressure and pain.
2. Smell of carious removal being not apparent.
3. Cutting speeds faster or equal the rotary. Instruments are easy to use.

Limitations

1. Only for areas of good visibility
2. No tactile guidance
3. Precise angles and margins difficult to obtain
4. Removal of gold and amalgam restoration time consuming.

21A Inlays and Onlays

Inlays are intracoronal restorations which are mostly fabricated outside the mouth and then cemented into the prepared cavers one or more cusps but not all the cusps.

MATERIALS USED FOR INLAYS

Type II and Type III gold alloys
Cobalt chromium alloys.
Nickel chromium alloys.
Porcelains
Composites

Indications for Inlays

1. Large cavities where amalgam restoration fractures often thereby requiring restorative material of higher strength.
2. When proximal cavities is extensive–In such cases the indirect method used to fabricate an inlay allow better control of contracts and contours. In cases where the gingival, margin of the cavity is extremely; subgingival or near the gingival attachment, proper margins can be achieved by inlays.
3. When the adjacent or opposing tooth were rehabilitated using cast metal restorations the involved tooth should be also restored with the same metal to prevent electrical and corrosive activity.
4. When there is need for additional extensions of the mesiodistal dimension of the tooth to favour contact with adjacent tooth inlays can be fabricated.
5. As cast metal restorations are superior to amalgam in many respects it can be fabricated for posterior teeth which are to serve as abutment for removable partial denture.
6. For restoration of teeth for patients who are allergic to amalgam to mercury.
7. Broad but shallow cavities where bulk of amalgam is needed to restore the teeth.

Contraindications of Inlay

a. In younger teeth, which have high pulp horns and incompletely mineralized dentin.
b. If amalgam restoration is present in the adjacent or opposing tooth it should be replaced with same metal inlay restoration before inlay is fabricated for the involved tooth.
c. Root canal treated teeth which cannot withstand bulky restorations.
d. When economic factors do not permit expensive cast metal restorations.
e. Small cavities which can be successfully restored with silver amalgam.
f. Patients showing evidence of high caries activity–in such cases it should be brought under control before cast metal restorations are fabricated.

Preoperative Evaluation of Occlusion

The evaluation of occlusion including occlusal contact during mandibular movement, occlusal contact intercuspal position should be done prior to operative procedure for inlays, also decide whether the existing occlusal relationship can be improved with cast metal restoration.

Basic Concepts of Cavity Design for Cast Restoration

Cast metals are superior to other restorative material in restoring extensively affected tooth as it is capable of supporting the remaining tooth tissue.

The cavity preparation has many fundamental differences from preparation for any restorative plastic material like amalgam.

a. Inlay taper (Fig. 21A.1): This is the basic requirement of all cavity preparation for inlay. The cavity walls must diverge from the floor of the preparation externally. This applies for intracoronal restorations (For the extracoronal preparation the walls should coverage from the cervical to the occlusal surface. This is called as 'concept of taper'. This taper permits
   1. unobstructed removal of the wax pattern
   2. subsequent sealing of the casting.

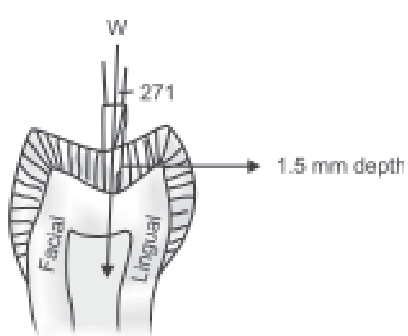


Fig. 21A.1: Mandibular Ist molar

Each intracoronal preparation has a line of draw which describes the path of insertion and in withdrawal of the casting. This is the axis of the taper. The axis of taper for a class I and class II preparation generally parallels the long axis of the tooth. This line of draw bisects the angle formed by the convergence of the tapered cavity walls to the point of insertion.

A total relationship of all prepared walls of the cavity is given by cone angle taper. A cone angle taper of 10-16º is used empirically as it produces adequate retention of the cemented casting. The amount of taper is influenced by the axial length of the preparation. Longer preparation requires high degree taper, shorter preparation requires taper in lower range.

b. Bevels (Figs 21A.2A and B): In order to have a better adaptation of the casting to tooth surface bevels are placed in the cavosurface outline of the preparation. This aids in forming a metal wedge of 25-35º.

To achieve this the joint between the casting and tooth surface can be either a tap joint (approximately 35º) or sliding lap joint 25º approximately.

Variation in Proximal Marginal Design

The proximal margins will vary with:

a. Amount of tooth structure loss
b. Location of tooth loss
c. Form of the tooth
d. Positional relationship with adjacent tooth
e. Need for retentive form
f. Convenience

The basic designs used to finish and extend walls and margins of the proximal box are:

a. Box preparation
b. Slice preparation
c. Auxiliary slice preparation
d. Modified flare preparation

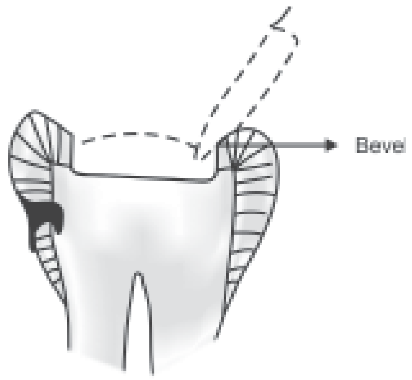


Fig. 21A.2A: Marginal bevel

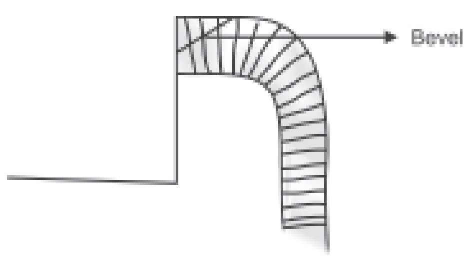


Fig. 21A.2B: Bevel

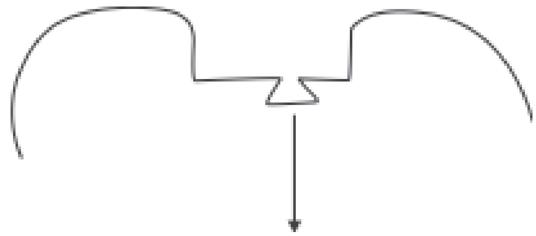


Fig. 21A.3: Box preparation

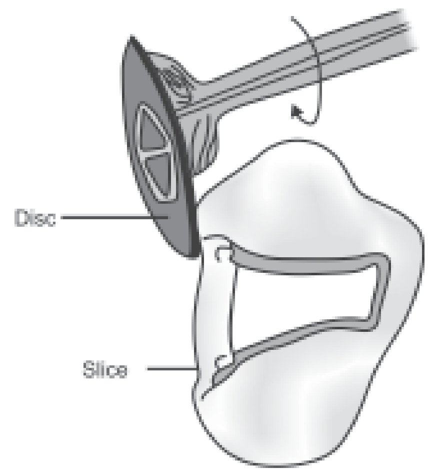


Fig. 21A.4: Slice preparation

Box Preparation (Fig. 21A.3)

This is principally used with proximo-occlusal preparation for the direct method of wax pattern formation.

The margins are prepared which permits greater bulk of wax in the preparation. The cavosurface formed by the proximal flare and the tooth structure is at right angles or slightly obtuse angles.

A cervical bevel is prepared with band instruments to form a lap joint between the wax and the tooth structure.

Slice Preparation (Fig. 21A.4)

This involves conservative disking of the proximal surface to establish the buccal and lingual extent of the finish line and provide a lap joint for finishing.

The slices are generally placed on the buccal and lingual proximal surfaces independently.

The slice may extended the cervical floor or more frequently terminates at some point occlusal to the cervical floor. The extent of slice is decided by the amount of tooth tissue which is presented by clinical and radiographic assessment. The slice can extent to the cervical floor if the tooth has a proximal contour square shape. But tooth with tapering or ovoid forms should have slice that extend short of cervical floor. Placement of proximal slice for indirect inlay products excellent definition for the finish line.

For better adoption of casting with tooth structure beveling of the proximal of cavosurface can be done.

Auxiliary Slice

This wraps partially around the proximal line angles thus providing additional support to the tooth.

Advantage: By this preparation

a. There is minimal tooth loss
b. Resistance is greatly enhanced reducing the chances of fracture

This can be also employed to provide external retention form. An auxiliary slice around the proximal line angle of the tooth. On the lingual side will prevent buccal. Similar is case with placement of auxiliary slice around the buccal proximal line angle to prevent lingual displacement of casting. This retentive method can be used when the proximal wall or any side is difficult to establish because of extensive tooth structure loss.

Modified Flare Preparation

It is some what a hybrid between box designs and slice preparation. In this tooth buccal and lingual proximal walls are initially formed with minimal extension. Then it is slightly disked in a plane that slightly reduces the proximal wall dimension, thus obtuseness of the surface angle is enhanced.

The types of design being selected depends upon mechanical consideration, biologic consideration and esthetic consideration.

In the mesiobuccals proximal margins of maxillary 1st and 2nd molar it is not advisable to use sliced preparation as there is display of the restoration.

Advantage: 1. Minimal tooth loss
2. Resistance is greatly enhanced (less chance of #)

Uses: 1. Support
2. External retention form

Advantages of Cast Restoration Over Other Restorations (Amalgam)

a. Cast metal alloys and ceramics used for cast restoration have better yield strength, compressive strength, tensile strength and shear strength. So can be used to restore areas of stress concentration within the tooth and also for reinforcing weakened tooth structure.
b. Cast restoration can be fabricated to reproduce precise form and minute details. They also maintain this detail under functional stress.
c. As one or more metal of the alloy is passivated they are not significantly affected by tarnish and corrosion in the oral environment. So they have improved clinical life, biologic qualities and better esthetics.
d. As the metallic restoration are built up instantaneously there will be linear voids and internal stresses as compared to incremental build up of amalgam. Thus, metallic restoration will have a stronger structure with less imperfection there by less susceptible to corrosion.
e. Cast restoration are finished, polished or glazed outside the oral cavity so there is no damage to pulp dentin due to heat or pressure.
f. As they reproduce contacts and contours precisely they aid in maintaining the health of supporting structures.
g. They can be used to make changes in the occlusion pattern which can be accomplished by amalgam.

h. They can be used in restoration of a teeth which is to serve as an abutment to fixed bridge where as amalgam cannot be used in such cases.
i. Cast restoration except high fused porcelain and cast ceramics can be used to restore subgingivally extending lesions.
j. They are comparatively less allergic than amalgam in sensitive patients.
k. In some cases cast restorations can be used to restore and splint cracked tooth as these restorations can prevent further crack. Propagation and occasionally promotes healing of minor cracks. Amalgam cannot be employed for this purpose.

Disadvantages of Cast Restoration Over Amalgam Restorations

a. More leakage around the restoration as it is a cemented restoration.
b. It necessitate extensive tooth preparation which can be hazardous to vital tissues.
c. Cannot be used in mouth having amalgam restoration due to the risk of dissimilar metal cell corrosion.
d. Requires more sittings as the fabrication procedures are lengthy.
e. More expensive than amalgam.
f. More risk of natural tooth abrasion in cases when natural tooth contacts the metal restoration. This can lead to teeth shifting, tilting or rotating also.
g. Should not be used in patients with high plaque or caries thus limiting its use.
h. Cannot be used in teeth incompletely mineralized dentin or high pulp horns.

Types of Bevels

According to their shape and types of tissue involvement bevel can be six type.

a. *Partial bevel (Fig. 21A.5A):* which involves part of the enamel wall not exceeding 2/3rd of its dimension. This is used to trim weak enamel rods from margins and is not usually used in cast restoration.
b. Short bevel (Fig. 21A.5B): includes the entire enamel wall but not dentin. this is used for cast restoration employing type III and II gold alloys.
c. Long bevel (Fig. 21A.5C): includes all the enamel walls and about half of the dentinal wall. It is used for types I, II, III and IV gold alloys, low gold alloys and non gold palladium based alloys.

The major advantage is that it preserves the internal boxed up resistance and retention features of the preparation.

d. Full bevel (Fig. 21A.5D): which includes dentinal and enamel walls of the cavity wall or floor. This deprives the preparation of its internal resistance and retention. It should be avoided except in cases where it is impossible to use other form of bevel.
e. Counter bevel: This is used when cusp capping is done to protect or support the cusps. It is used opposite to the axial cavity wall on the facial or lingual surface of the tooth with a gingival inclination facially or lingually.
f. Hollow ground bevel/concave bevel: (Figs 21A.5E and F) Bevels can be prepared in a concave form so that it allows more space for cast material bulk. This is needed in special preparation to improve material castability retention and better resistance to stresses.

This bevels (can be any type) is ideal for class IV and V cast materials (nickel chromium alloys, castable ceramics, mouldable ceramics).

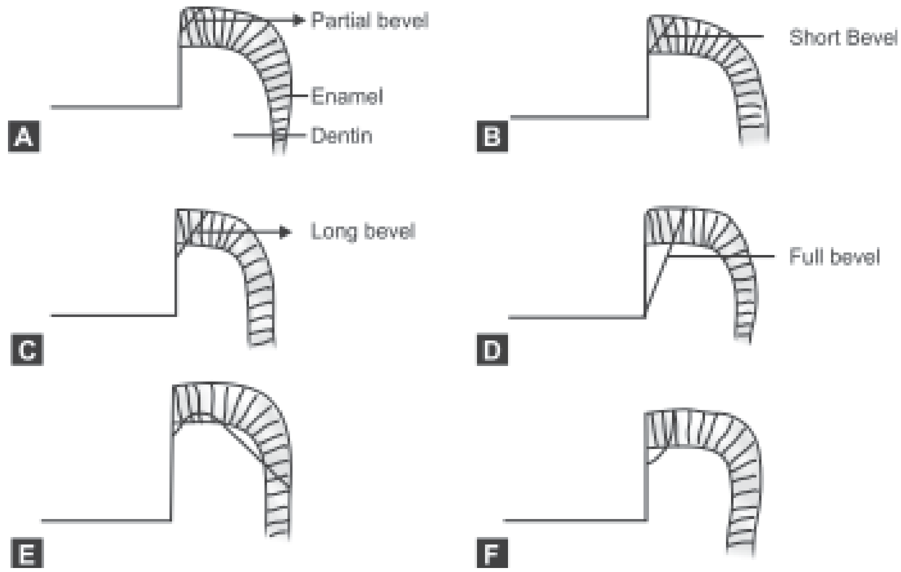


Fig. 21A.5: Types of bevels

Factors that Affect Cavity Design for Cast Restorations

a. Length of the clinical crown
b. Occlusal, proximal, buccal and lingual anatomic characteristics
c. Portion of the tooth in the arch
d. Occlusal and proximal relationship of the tooth
e. Relationship and condition of the surrounding soft tissue
f. Extend and location of carious lesion

Principles of Cavity Reparation for Cast Gold Restorations

Outline Form (Fig. 21A.6)

External Outline Form: Basically the external outline form for cast gold restoration should consist of straight lines and smooth following curves without any sharp angles. The outline form should include retentive features or other faults on the occlusal surface and on the proximal surface it should be extended till all the caries is removed.

At the cavosurface margin no unsupported enamel should be left behind. The margins should allow sufficient areas for finishing the preparation and for castings.

The external outline for class 3 gold inlay follows the similar external outline form for

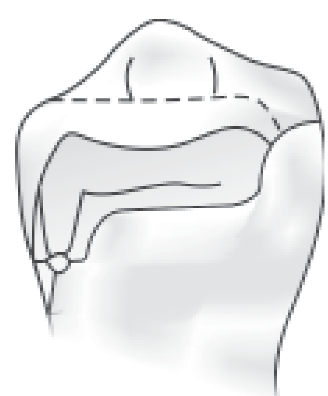


Fig. 21A.6: Cast gold restorations cavity form amalgam but the walls of the prepared cavity should not have any undercut. This is achieved by aligning the long axis of the bur parallel to the long axis of the tooth crown this holds good for the occlusal portion of class II preparation.

In the proximal outline form the concept of taper is included. The walls of the cavity diverge from the floor to the preparation. This cone angle taper (approximately 10-16°) allows unobstructed removal and insertion of the casting.

Modification: (in max molars, mandible, premolars)

Some teeth need certain modification in the outline form. Some of these can be prediated while other are developed according to the circumstances.

In maxillary molars there will be a oblique ridge extending from the distobuccal cusp to the mesiolingual cusp. This divides the occlusal surface into mesial and distal segments. If this oblique ridge is not undermined by caries or crossed by retentive fissure it is not included in the preparation but kept intact. So instead of a single MOD restoration the maxillary molar will frequently have a MO and a DO restoration.

In mandibular first premolar there will a transverse ridge separating the occlusal surface into mesial and distal segments. If this transverse ridge is not affected by caries it is not included in the preparation there by having two restorations.

Other factor that necessitates modification of outline form are unusual occlusal relationship like cross bites and unusual esthetic consideration.

Internal Outline Form

While the internal outline form is established the histologic and biologic factors must be considered.

The pulpal floor and the axial wall of the preparation must be straight. Care should be taken to maintain a suitable thickness of dentin between the restoration and the pulp. Whenever the pulpal floor or the axial wall is to be extended beyond the usual limits due to extension of caries or injury the additional thickness of dentin removed is replaced with appropriate cement for pulp protection.

The concept of taper applies to cavity preparation for inlays. The degree of taper depends on the depth of the preparation from the occlusal or cervical aspect. But in all instances the tape should be visible to the eye on inspection. The taper should not be too much as it affects the retention form of the preparation. Deeper cavities require higher degree of taper to facilitate seating of the castings. Insufficient taper to achieve better fit can cause fracture of the remaining tooth structure.

Generally the pulpal floor is placed approximately 0.5 mm into dentin. This provides adequate retention for the casting by virtue of resilient property of dentin.

The gingival seat is positioned in sound tooth structure. In most cases it in enamel and dentin but in deeper preparation it may be in cementum and dentin. The bevel is placed in the gingival margin to establish the finish line.

Line angle in both occlusal and proximal preparation should be well defined. The axio pulpal line angle should be rounded to prevent concentration of stresses within the casting. The axio proximal line angles is rounded slightly. The flare of the proximal walls should form axioproximal line angle of 100-110°.

The integrity of the marginal ridges should be enhanced by providing sufficient taper to these walls. This allows adequate dentinal support to the enamel thereby its integrity. If a fissure terminates near the marginal ridge, create an exaggerated taper by malining the cutting instrument. This protects the thin wall of enamel that remain at the cavosurface.

If there are any modification like buccal or lingual groove extensions prepare the extensions with the floor, floor of the walls and taper concept. Bevels are also gives at the cavosurface for establishing proper finish line.

Resistance and Retention Form (Fig. 21A.7)

The castings are cemented into the prepared cavity. The strength of cement bonding is not a means of sufficient retention for the castings. The cement may fracture on compression or tension leading to release of restoration from the prepared cavity if this retentive factor alone is employed.

Correct taper of the cavity walls of the preparation is an important factor in providing satisfactory resistance and retention form. If the degree of taper is excessive there will be loss of frictional grasp between the castings and tooth structure.

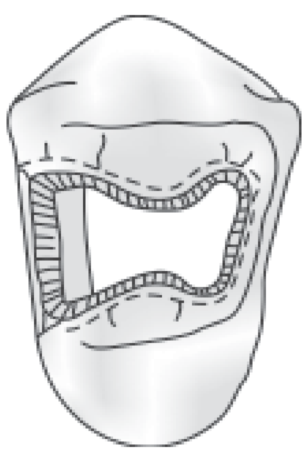


Fig. 21A.7: Occlusal view of resistance and retention form

This can also allow rotational displacement of the casting. At the meantime it should be sufficient to allow proper seating of the casting in the prepared cavity.

The pulpal floor and the gingival seat should be designed. Perpendicular to the line of forces that will influence the casting. Such positioned floors absorb the stress over a broad area of the tooth and prevents dislodgement of castings as well as fracture of the tooth tissue.

Another important factor in obtaining resistance and retention form is well defined line angles. This aid in retaining the precise relationship between the tooth structure and casting.

Rounding of the axiopulpal line angle is important in preventing fracture of the casting as sharp axiopulpal line angle can concentrate stress at the area.

Slice preparation is frequently employed to increase the resistance and retention form. This procedure express larger amount of tissue surface to the frictional grasp of the casting. This can be also accomplished by auxiliary slice preparation which allow the restriction to envelop the line angles of the tooth to provide greater resistance and retention form.

Another major factor is resistance and retention form is occlusal interlock or dovetail. This prevents lateral displacement of the inlay and provided retention against forces of stick food by creating greater surface area of tooth tissue in contact with the casting.

Specially designed features incorporated in cavity design to improve retention and resistance form include, pinholes, or post holes tapered grooves. These are given when the resistance and retention obtained from usual cavity design is inadequate.

Pinholes/post holes are placed parallel to the line of draw of the casting. This primarily prevents rotational displacement as more frictional grasp between the tooth structure and gold is obtained.

Tapered grooves extending from gingival seat to the occlusal surface are placed in the dentin portion of the proximal walls. This prevents lateral displacement of the casting by forming a keying lock.

Removal of Any Remaining Infected Dentin

After cavity preparation cumulate the internal walls of the preparation visually and tactilely with an explorer to detect any remaining soft dentin. If infected dentin is still present remove it by slow revolving round bur or spoon excavator. This is only done if there is adequate breadth of dentin between the walls and the pulp.

If the carious lesion is judged to be closely approaching the pulp rubber dam isolation is mandatory to provide optimal environment for pulp treatment in case of any pulpal exposure.

Excavation of dentin should continue till the remaining dentin.

If pulpal exposure occur during caries removal, root caries of be performed before completing the cast metal restoration.

If pulpal exposure is due to operator error judgement mechanical pulpal exposure decision should be taken whether to perform root canal filling or direct pulp capping. If the excavation closely approaches the pulp perform indirect pulp capping.

Convenience Form

This provides accessibility and visibility required to complete operative procedure thoroughly and accurately.

Enamel that is not supported by sound dentin must be removed using a hand instrument.

The convenience form include extension taper, flare of proximal walls to permit access for disking and bevel placement, extension to allow paper finishing and adaptation of margin of restorative material.

Finishing Enamel Walls and Margins

Regular diamond points and cross cut fissure bur leave a roughened surface which may hamper adaptation of the gold, restoration to the walls and margins of the cavity. This may even occurs with hand instruments used to smoothen enamel and dentinal walls. So the surface should be made smooth to have smooth on the impression as well as pattern to be reproduced in the casting. The walls and margins can be smoothened to some extend using carbide finishing burs of fine abrasive disks.

The bevel in the cervical margin should be well defined as it establishes the cervical finishing line. This can be accomplished by flame shaped extra finishing bur.

Whenever tapered walls of the inlay preparation forms a butt type joint with the cavosurface margin bevels are to be given to facilitate finishing.

Final Procedure of Cleansing and Inspecting the Cavity

Clean the cavity walls, floors and margins with air water spray after completing the cavity preparation.

Dry the cavity with cotton pellets or gentle stream of warm air and inspect all aspects of the cavity.

A trial impression is very useful to evaluate taper and line of draw of preparation. This is done employing compound as even relatively minute undercuts are readily apparent in the impressions. It also gives details regarding bevels, line angles and definition of the finish line.

DIFFERENCE BETWEEN CAVITY PREPARATION FOR AMALGAM AND CAST INLAYS

Black's principles of cavity preparation in applied for both amalgam and cast inlay but there are certain modification to be carried out in cavity preparation for inlay. The differences can be noted as –

a. The outline form for inlay preparation is more extended and is under than that of amalgam preparation for newer amalgams. This facilitates support for the tooth by the inlay.
b. The outline form must be extended to include all the defects and related fissures and grooves. It must be also extended faciolingually and gingivally for convenience form to permit finishing and adapting the casting to the cavosurface.
c. The box like internal outline form can be reduced in inlay preparation since resistance is not of much importance as in amalgam preparation.
d. The cavity walls of inlay preparation are tapered and placed in inlay preparations as bulk is generally not present in inlays comparative to amalgam.

   The taper also facilitate withdrawal of the pattern and seating of the cavity.

e. The axio pulpal depth of the preparation is limited when compared to amalgam preparation as bulk is not necessary to resist fracture. The walls are placed just inside the DEJ in inlay but in amalgam it should be 0.5 mm in the dentin as bulk is essential for resistance form.
f. Retention of casting is formulated by dovetail taper of the walls, port holes, grooves, cusp capping and surface reduction.
g. The preparation for inlay will have a single insertion path opposite to occlusal loading. This is achieved by –
h. Inlay preparation for class II the proximal region are opened to all place of faciolingual margin closer to line angles. This place the margin in the self cleansing area and present plaque accumulation or caries on the edge of restoration the gingival wall is placed out of contact with adjacent tooth and is extend to the level of amalgam preparation.
i. Cavosurface margin of the preparation is beveled where the wall approaches a right angle. This creates bulk on the edge of tooth structure. This aids in seal of the retention. But in amalgam butt joint is given as amalgam do not have adequate edge strength.
j. Secondary flare are given in inlay preparation to have a marginal metal angle and approximately 40º. This is blend with the gingival level.

21B Contours and Contact

CONTOUR

Contour is the external anatomy of the tooth.

CONTACT

Contact is the area/point where a tooth contacts the adjacent tooth.

The contours can be buccal/labial contour, lingual/palatal, mesial, distal, occlusal contour.

Point contact is seen in anterior tooth whereas contact area is the feature of posterior teeth. Depending on the shape of teeth, the contact area can be tapering, square or ovoid.

Location of Contact

In the anterior teeth, the contact is usually at the middle 3rd of the tooth.

In the premolar, the contact area will be at the junction of the middle 3rd and coronal 3rd.

In the molar, a more bulky contact area will be located more cervically. So as we progress from incisor to molar, the contact will be located more cervically resulting in more larger embrasures.

Importance of Contours and Contacts

a. They are essential to maintain balanced occlusion.
b. They prevent food impaction.
c. They are significant in preventing periodontal problems, caries and halitosis as a sequelae.
d. They prevent tooth movement and overeruption thus facilitate functions and prevent TMJ disorders.
e. They are necessary for normal physiologic stimulation of the supporting structure and its health.

Intraoral procedures for creation of contacts and contours in restoration.

a. Tooth movement separation, wedging.
b. Matricing
c. Proper finishing of restoration

Extraoral procedures for creation of contacts and contours in cost restoration.

a. Proper contouring of wax pattern.
b. Cast adjustments partly on models and partly intraorally.

Material Used to Build up Contact

Anteriorly: composites, reinforced glassio-nomer
Posteriorly: amalgam, posterior composites, cast restoration

Causes of Disturbances in Contact

a. Physiological – midline aiasterna, spacing rotation

b. Food impaction, plunger cusp
c. Fracture of teeth
d. Habits – unnecessary tooth picking, tailer placed needle between teeth
e. Proximal caries
f. Improper orthodontic force
g. Jaw fracture
h. Improper restoration
   - improper cavity preparation, improper matricing
   - improper wedging, improper contouring
i. Missing tooth–drifting of teeth, supra-eruption of opposing teeth

22 Silver Amalgam

INTRODUCTION

Ever since its introduction in dentistry, amalgam has been a matter of controversy. Having faced 4 amalgam was in its life span of about 160 years, silver amalgam is still the restorative material of choice.

Consumer reports in America summed up in this way – "Gives their solid track record and a risk that's still conjective, amalgam fillings are still your best bet".

This seminar attempts to review the material and its properties which make it our best bet as a restorative material.

HISTORICAL ASPECT

Dental amalgam was developed in 1800's is France and found its way in 1833 is U.S.A.

The composition of dental amalgam was improved greatly by work of Flagg and Black.

In 1920, ADA gave sp no. I about amalgam which are discussed in text.

In 1960, high copper amalgam alloys were introduced.

Definition

As amalgam is defined as a special type of alloy in which mercury is one of the constituents.

Dental amalgam is an alloy of mercury, silver, copper and tin, which may also contain palladium, zinc and other elements to improve handling characteristics and clinical performance.

Dental amalgam alloy is an alloy of silver, copper, tin and other elements that is formulated and processed is the form of powder particles or as a compressed pellet.

Advantages

- High crushing strength
- Insolubility in oral fluids
- Good adaptability to cavity walls
- Convenience and ease of manipulation
- Compatibility of taking polish
- Economical
- Reasonably long service.

Disadvantages

- Inharmonious color
- Tendency for molecular change
- Poor edge strength
- High thermal conductivity
- Prone to tarnish and corrosion
- Marginal deterioration
- Mercury toxicity

Generations

i. Silver and tin (3:1)
ii. Silver, tin, copper (4%), Zinc (1%)
iii. Silver eutectic added to original alloy powder
iv. Copper content increased to 29%

v. Addition of indium
vi. Palladium (10%), silver (62%) and copper (28%) eutectic alloy added to I, II and III generations.

Classification

i. Based on copper contact
   - Low copper (< 6%)
   - High copper (> 6%)–admixed/dispersion alloys–unicompositional
ii. Based on zinc contact
   - Zinc containing (> 0.01%)
   - Zinc free (≤ 0.01%)
iii. Based on shape
   - Lathecut
   - Spherical
iv. According to no of alloyed metals
   - Binary eg. Ag-Sn
   - Tertiary – Ag-Sn-Cu
   - Quaternary – Ag-Sn-Cu-In
v. According to size of alloy
   - Microcut
   - Macrocut.

COMPOSITION

Role of Individual Constituents

Silver

- Unites readily with mercury is definite proportions
- Expansion on setting
- Retards setting of mass
- Increases edge strength
- Decreases flow
- Whitens the alloy
- Tarnishes from action of sulphides
- Amalgamates slowly and with difficulty.

Tin

- Unites readily with mercury in all proportions
- Increases flow
- Retards setting of mass
- Imparts plasticity to mass
- Contracts on setting
- Decreases edge strength
- Controls reaction between silver and mercury
- Reduces resistance to tarnish and corrosion.

Copper

- Unites with mercury with difficulty is definite atomic proportions
- Accelerates reaction of setting
- Decreases flow
- Shows no appreciable contraction or expansion
- Increases hardness and strength
- Tarnish rapidly in presence of sulphides

Table 22.1: High copper

	Low copper	*Admixed*		*Single composition*
Constitution	Lathecut or spherical	Lethecut(2/3)	Spherical (1/3)	Spherical
Silver	63-70%	40-70%	40-65%	40-60%
Tin	26-28%	26-30%	0-30%	22-30%
Copper	2-5%	2-30%	20-40%	13-30%
Zinc	0-2%	0-2%	0	0-4%

Zinc

- Acts as scavanging agent
- Decreases edge strength
- Imparts plasticity to mass
- Accelerates setting.

Mercury

In some formulations a small amount of mercury (upto 3%) is added to alloy, usually just sufficient to cover the surface of alloy particles. They are called as preamalgamated alloys. This preamalgamation produces more rapid reaction.

Platinum

- Hardens the alloy
- Increases resistance to corrosion.

Palladium

- Hardens the alloy
- Whitens the alloy.

MANUFACTURE OF ALLOY POWDER

Lathe Cut Alloy Powder

The ingredient metals are melted in a protected environment and poured into a mold to form an ingot. Ingot is cooled slowly. This is followed by homogenization i.e. ingot is heated for varying periods of time (6-8 hrs) at 400ºC. Annealed ingot is placed in a milling machine or is lathe and fed into a cutting tool.

Spherical Particles

Prepared by Atomization

All the desired elements are melted together and the liquid alloys is then sprayed under high pressure of an inert gas through a fine crack is a crucible into a large chamber. The sprayed particles may be spherical or some what irregular.

Amalgamation

Amalgamation occurs when mercury comes into contact with the surface of the AgSn alloy particles. On trituration, Ag and Sn is outer portion dissolve into Hg. Also Hg diffuses into the alloy and reacts with Ag and Sn.

In case of low copper alloys.

$$\underset{(r)}{Ag_3Sn} + Hg \rightarrow \underset{(r_1)}{Ag_2Hg_3} + \underset{(r_2)}{Sn_8Hg} + \underset{(r)}{Ag_3Sn}$$

In case of high copper alloys, Cu content is > 6%.

Admixed Alloys

There is 1 part Ag-Cu eutectic and 2 parts Ag-Sn. As the solubilites of Hg in Ag, Sn and Cu differ so particles of Ag and Sn dissolve almost all the Hg and very little Hg will be dissolve by Ag-Cu eutectic. So same reaction as for low Cu alloys follows in a short time, r_2 phase reacts with Ag-Cu particles forming Cu_6Sn_5 (n) phase along with same r_1 phase.

$$\underset{(r)}{Ag_3Sn} + \underset{(E)}{AgCu} + Hg \rightarrow \underset{(r_1)}{Ag_2Hg_3} + \underset{(r_2)}{Sn_{7\text{-}8}Hg} + \underset{(r)}{Ag_3Sn} + \underset{(E)}{AgCu}$$

$$Sn_{7\text{-}8}Hg + AgCu \rightarrow \underset{R}{Cu_6Sn_5} + \underset{r_1}{Ag_2Hg_3}$$

r_2 which is the weakest phase is eliminated in this reaction.

Single Composition Alloys

Again as a result of difference in solubility, the Sn in the periphery of particles will be depleted by the r_2 phase while the % of Cu will increase as a result of limited reaction so in early stages r_1 and r_2 phase are formed and then r_2 phase reacts with Ag-Cu forming n and r_1.

$$\underset{(r)}{Ag_3Sn} + \underset{(E)}{Cu_3Sn} + \underset{(r_1)}{Hg} \rightarrow \underset{n}{Cu_6Sn_5} + Ag_2Hg_3$$

Strength of Various Phases

r is strongest phase followed by r_1, r_2 and voids.

Corrosion of Various Phases

r_2 is most corrosive followed by r_1 and r.

PROPERTIES OF AMALGAM

Microleakage

Microleakage i.e. penetration of fluids and debris around the margins of a restoration may cause 2 degree caries. Amalgam minimizes microleakage because of formation of corrosion products in the interface between tooth and restoration which seal the interface.

Accumulation of corrosion products is slower in high Cu alloys.

Dimensional Change

Dental amalgam contracts or expands depending on its manipulation.

ADA spe. No. 1 requires that amalgam should not expand or contract more than 20 mm/cm at 37°C between 5 minutes and 24 hours after beginning of trituration.

On mixing contraction results as the particles dissolve and r_1 grams. The final volume of r_1 is less than total initial volumes of dissolved Ag and Hg. Contraction continues as long as growth of r_1 continues while according to expansion theory, r_1 crystals, as they grow impinge against one another producing as outward pressure tending to oppose contraction.

Effect of Manipulation

If there is sufficient Hg present to provide a plastic matrix, as expansion will occur when r_1 crystals impinge. After a rigid r_1 matrix has formed, growth of r_1 crystals can not force the matrix to expand. Instead r_1 crystals will grow into interstices containing Hg producing continued reaction.

Less Hg in mix favours contraction

Eg. – lower Hg alloy ratio
- higher condensation pressure
- longer trituration time
- use of smaller particle size

Effect of Moisture Contamination

In Zinc containing alloy amalgam is contaminated by moisture during trituration or condensation, a large expansion can take place due to H_2 gas produced by electrolytic action.

$$H_2O + Zn \rightarrow ZnO + H_2 \text{ (Gas).}$$

This expansion usually starts after 3 to 5 days and may continue for months reaching values greater than 400 um (4%). This is known s delayed/secondary expansion.

Zinc free alloys do not show this type of expansion.

Effects of Delayed Expansion

The H_2 gas produced does not combine with amalgam but collects within the restoration creating extreme interval pressure within the mass and results is expansion of the amalgam. This causes:

- protrusion of restoration out of cavity
- increased creep
- increased microleakage
- pitted surfaces

- corrosion
- dental pain
- recurrence of caries
- fracture of the restoration

Strength

Compressive strength of a satisfactory amalgam should be atleast 310 MPa (45000 psi)

Alloy	C.S. (psi) 1 hr	C.S. 7 days	T.S. 24 hrs
Low copper	21000	49800	8700
Admixed	19800	62600	7000
Single composition	38000	73900	9300

Effect of Trituration

Effect of trituration on strength depends upon
- type of alloy
- trituration time
- speed of amalgamator

Under as well as over trituration causes strength for both low and high Cu alloy.

Effect of Mercury

Strength is related to amount of unconsumed alloy particles and mercury containing phases.
- Lower Hg content leads to move alloy particles and less matrix phase
- Increasing final Hg content increases volume of Hg phases at expansion of alloy particles. Thus amalgam with excess amount of Hg are weak.

Effect of Condensation

- Higher condensation pressure with good condensation technique minimizes porosity and excess Hg from lathe cut amalgam resulting in less volume fraction of matrix phases.
- If heavy pressures are used in spherical amalgam, condensor will punch through amalgam. Spherical amalgams condensed with lighter pressures produce adequate strength.

Effect of Porosity

Voids and porosity reduces strength of hardened amalgam.

Effect of Rate of Hardening

Amalgams do not gain strength as rapidly as might be desired. At end of 20 min, C.S. may be only 6% of 1 week strength. According to ADA specification minimum C.S. at 1 hr – 80 MPa.

Creep

It is defined as time dependent plastic deformation. According to ADA sp. No. 1, creep rate should be below 3%. Creep values for high Cu alloys is 0.4% or less.

Low Cu amalgam – 0.8-8.0%
High Cu amalgam – 0.4-1.0%

Mercury Alloy Ratio

The mercury content of finished restoration should be comparable with that of original mercury alloy ratio, usually approximately 50 wt% i.e. 1:1 s given by Eames Technique.

For spherical alloys lesser ratio i.e. 42 wt% is used.

Various delivery systems are available.
- Dispensers
- Tablets
- Disposable capsules

Trituration

The main objective of trituration is to wet all the surfaces of the alloy particles with Hg. Rubbing of particles through same mechanical process removes away the oxide film coated on alloy particles. The clean surface of particles now is wetted in presence of Hg.

Hand Trituration

- Uses glass morter and pestle
- In a properly triturated amalgam the no. of rotations as pestle pressure must be properly regulated and standardized for ever mix by the operator for uniformity of result.
- A moderately firm pressure of 800-900 gms is quite adequate.

Mechanical Trituration

- Reduces mixing time and procedures is more readily standardized

Work of Trituration

Time × pressure × no. of rotations.
The work of trituration should remain constant.
In hand trituration – pressure – 2-3 pounds
No. of revolutions – 200 rpm
Time – 30 to 60 sec.
Mechanical trituration → Time (8-20 sec) × motor speed × capsule pestle action.

- Under triturated mix is rough and grainy and this may crumble and offers less resistance to tarnish and corrosion. Also strength is less.
- Normal mix has a shiny surface with smooth, soft consistency. Mix may be warm when removed from capsule. The strength is more and has increased resistance to tarnish and corrosion.
- Over triturated mix is too soupy and too plastic to manipulate. The working time is decreased and results in higher contraction of amalgam compressive strength and tensile strength of lathe cut alloys are increased while decreased in high Cu alloys. The creep is increased.

Mulling

This is actually continuation of trituration. It is done to improve the homogenisity of the mass and get a consistent mix.

This is achieved by holding the mass is finger and thumber is a rubber finger stoles or a chemosis skin. The mass in removed when it in smooth. It has a silvery gray surface and does not stic to the walls of mortar.

Condensation

Purpose is to
- Adapt material to cavity walls
- Remove excess mercury
- Enhance packing of amalgam particles and reduce risk of void formation
- Increases strength and decreases creep

Longer the time between mixing and condensation, weaker the amalgam. The condensation of partially set material fractures and breakup the matrix that has already formed. Hg content and creep are increased.

Amalgam which is 3-4 min old should be discarded because it has lost considerable amounts of plasticity so that it is difficult to condense without causing voids.

Condensation may be
- Hard
- Mechanical

Hard condensation is done with condensers which are serrated.

Generally, 3-4 pounds pressure is applied and 2 mm diameter condensers are used. The material should be over packed about 1 mm so that it is removed for final carving.

For mechanical condensations, automatic devices are available. Impact type of force and rapid vibrations are used. It is less tiring for operator.

CARVING AND FINISHING

Precarve Burnishing Procedure

It is a form of condensation to ensure that marginal amalgam is well condensed before carving, the overpacked (1 mm) amalgam should be burnished immediately with a large burnisher using heavy strokes mesiodistally and faciolingually. This produces denser amalgam at margins of occlusal preparations.

Carving

Filling is carved to reproduce proper tooth anatomy. Carving should not be started until the amalgam is hard enough to offer resistance to carving instrument. A scrapping or ringing round should be hard when it is carved.

All carving should be done with the edge of the blade perpendicular to the margins as the instrument is moved parallel to the margins. Part of the edge of the carving blade should rest on the unprepared tooth surface adjacent to cavity margin with strokes proceeding from tooth surface to amalgam surface.

Post Carve Burnishing

After carving, restoration should be smoothened. This is done by burnishing the surface and margins of restorations. Fast setting alloys gain sufficient strength by this time to resist rubbing procedure.

Final smoothing can be done by rubbing the surface with a moist cotton pellet or by a rubber polishing cup and paste.

Polishing

- The objective is to remove the superficial scratches and irregularities. This minimizes corrosion and prevent adherence of plaque.
- Polishing should be delayed for at least 24 hrs after condensation or preferably longer.

Mercury Toxicity

- Mercury can be hazardous if not managed properly.
- Mercury absorbed in to circulatory system may be deposited in brain, liver and kidney or any other tissue.
- Mercury ions circulate readily in blood but pass membrane barriers of brain and placenta only with difficulty.
- Non ionized mercury is capable of crossing through lipid layers at these barriers and if oxidized, is slowly removed but this mercury level from dental amalgam is very low. Also, mercury does not collect irreversibly in tissues.
- Effects of mercury on fetal development are not fully understood. But various surveys indicate that female dentists, assistants and hygienists who are pregnant are at no higher risk to miscarriage or fetal misdevelopment.

Pronounced Symptoms

- Kidney inflammation
- Swollen gums
- Pronounced tremor and nervous system disturbances

Mild to Moderate Symptoms

- Irritability, depression, memory loss, minor tremor, and other nervous system disturbances
- Early signs of disturbed kidney function

Subtle Changes on Some Tests but No Overt Symptoms

- Decreased response on tests for nerve conduction, brain-wave activity, and verbal skills

DENTAL MERCURY HYGIENE RECOMMENDATIONS

1. Symptoms: Know the potential hazards and symptoms of mercury exposure such as the development of sensitivity and neuropathy.
2. Hazards: Know the potential sources of mercury vapor such as: (a) spills, (b) leaky dispensors or capsules, (c) polishing amalgams, (d) removing amalgams, and (e) heating of amalgam-contaminated instruments.
3. Ventilation: Provide proper ventilation in the workplace by having fresh air exchanges and periodic replacement of filters which may act as traps for mercury.
4. Monitor Office: Monitor the mercury vapor level in the office periodically. (This may be done by using dosimeter badges.) The current OSHA limit for mercury vapor is 50 microgram/cubic meter (time weighted average) in any 8-hour work shift over a 40-hour work week.
5. Monitor Personnel: Monitor office personnel by periodic analysis. (The average mercury level in urine is 6.1 ug/litre for dental office personnel.)
6. Office Design: Use proper work area designed to facilitate spill contaminent and clean up.
7. Precapsulated Alloys: Use precapsulated alloys to eliminate the possibility of a bulk mercury spill. Otherwise store bulk mercury properly in unbreakable containers on stable surfaces.
8. Amalgamator Cover: Use an amalgamator fitted with a cover.
9. Handling Cover: Use care in handling amalgam. Avoid skin contact with mercury or freshly mixed amalgam.
10. Evacuation Systems: Use high volume evacuation when finishing or removing amalgam. Evacuation systems should have traps or filters. Check, clean, or replace traps and filters periodically.
11. Masks: Change mask as necessary when removing amalgam restorations. (The mask will trap airborne particles and may discourage vapor transport but will not stop vapor passage.)
12. Recycling: Store amalgam scrap under radiographic fixer solution in a covered container. Recycle amalgam scraps through refiners who are properly licenced by the EPA. Find out how long the company has been in business and what are its assets.
13. Contaminated Items: Dispose of mercury-contaminated items in sealed bags according to applicable regulations.
14. Spills: Clean up spilled mercury properly by using trap bottles, tapes, or fresh mixes of amalgam to pick-up droplets; or use commercial cleanup kits. Do not use household vacuum cleaner.
15. Clothing: Wear professional clothing only in the dental operatory.

Effect of Excess Mercury on Restorations

- Decrease in strength
- Corrosion
- Increase in creep
- Marginal fracture
- Surface deterioration
- Secondary caries

Effect of Less Mercury on Restorations

- Increase is strength
- Contraction
- Increase is corrosion resistance
- Decrease in creep
- Less tendency of marginal fracture

Dental Mercury Hygiene Recommendations

1. Symptoms–now the potential hazards and symptoms of mercury exposure such as development of sensitivity and neuropathy.
2. Hazards–know the potential sources of mercury vapour such as (a) spills (b) leaky dispensers (c) polishing (d) remaining amalgam (e) heating of amalgam contaminated instruments.
3. Ventilation–have fresh air exchanges and periodic replacement of fifties.
4. Monitor Office–Monitor mercury vapour level in office periodically (50 ug/m^3 is any 8 hr work shift over a 40 hrs work week)
5. Monitor Personnel–monitor office personnel by periodic analysis (urine level–6.1 ug/l).
6. Office Design–Work area should be designed to facilitate spill contaminant and clear up.
7. Precapsulates Alloys–Eliminate the possibility of mercury spills.
8. Amalgamator Cover–Use an amalgamates fitted with a cover.
9. Handling Cover–Use care is handling amalgam; avoid skin contact with mercury or freshly mixed amalgam.
10. Evacuation systems – evacuation systems should have traps or filters.
11. Masks – Discourage vapor transport.
12. Recycling – Store amalgam scraps under radiographic fixer solution and recycle them through refiners.
13. Contaminated Items–Dispose is sealed bags.
14. Spills–Clean up spills using trap bottles, tapes or fresh mixes to pick up droplets or clean up kits or vacuum cleaner.
15. Clothing–Wear professional clothing only is dental operatory.

SYMPTOMS OF MERCURY TOXICITY

Systemic

- Gastric disturbances
- Diarrhea
- Excitability
- Insomnia
- Headache
- Irritability
- Photophobia
- Red/pink skin
- Cold clammy feeling
- Maculopopular rash
- Mental depression
- Fine tremors of fingers, limbs, lips and tongue
- Desquamative dermatitis
- Nephritis

Oral

- Ptylism
- Metallic taste
- Salivary glands swollen
- Macroglossia and painful
- Hyperemia and swelling of gingiva
- Prone to ulcerations
- Pigmentation of gingiva
- Loosening of teeth

Clinical Considerations

1. Amalgam is the least technique sensitive permanent restorative material.
2. Life Expectancy – for Cl I restoration – 15-18 years
   Cl II restorations – 12-15 years

Also patients maintenance of hygiene can contribute to an even longer service by the restoration.

3. IT gains 70% of its strength is 8 hrs.
4. For strength, amalgam needs sufficient bulk i.e. a thickness of 1.5 mm or more is needed to withstand occlusal forces.
5. An acidic environment promotes galvanic corrosion, poor oral hygiene and cariogenic diet will expose both teeth and restorative material to a destructive environment.
6. Cavity vanish is pointed in cavity to reduce initial leakage by sealing the margins before corrosion products form.

23 Tooth Separation

Tooth separation in operative dentistry is the judicious separation of the teeth in order to facilitate the creation of physiologically functional contact and contour in the restored tooth.

REASONS FOR TOOTH SEPARATION

1. To provide room for the matrix band interproximally without interfering with the mesiodistal dimension of the restoration thus creating a positive tight contact.
2. For facilitating access to proximal cavity preparation especially class preparation.
3. For ease of finishing the restoration in the proximal surface.
4. For providing additional diagnostic information when radiographs do not clearly show initial carious lesion in the contact area.
5. For moving teeth from non functional or traumatically functional location to a physiologically functional location.
6. For repositioning drifted teeth, in case of proximal caries or faulty proximal restorations there could be collapse of mesiodistal contact relationship. In such cases the normal amount of supporting tissue is reduced. This can lead to periodontal problems. So separation in such instances aids in return of proper physiologic volume of supporting tissue moreover re-establishment of lost mesiodistal dimension leads to better occlusal harmony.

Methods of Tooth Movement

There are two principle methods of tooth movement

a. Rapid/immediate tooth movement
b. Slow/delayed tooth movement

RAPID/IMMEDIATE TOOTH MOVEMENT

This is a mechanical type of separation that creates proximal separation.

Besides general indications it can be used as preparatory for slow tooth movement or can be used to maintain the space gained by slow separation.

This type of separation should not exceed the thickness of the involved tooth's periodontal ligament. If this exceeds the ligament will tear at one side and crush at other side. The optimum separation is about 0.2-0.5 mm.

The methods of rapid separation are:

Wedge Method

In this the separation is accomplished by the insertion of a pointed wedge shaped device between the teeth. As the wedge moves facially or lingually separation occurs.

Examples of this type of separation are :

* *Elliot separator (Fig. 23.1):* This is indicated for short-term separation that do not require stabilization and is useful in examining proximal surfaces and for final polishing of restored contacts.

The two opposing wedges of the separator are positioned interproximally, slightly below the contact area. The wedges should not impinge on the interdental papillas. Move the knob clockwise which moves the wedges towards one another, thereby producing separation.

Wood/plastic wedge (Fig. 23.2): They are triangled shaped wedges usually made of medicated wood or synthetic resin.

In cross section the base of the triangle should be in contact with the interdental papilla and is positioned in such a manner that the apex is slightly gingival to the gingival margin of the proximal cavity.

The available wedges are trimmed to exactly fit each gingival embrassure.

For instantaneous separations of teeth during operative procedures in anterior teeth like planing the axial walls, accentuating line angles or polishing proximal surfaces of class III restoration the nail of the finger can be wedged between the teeth to provide rapid separation.

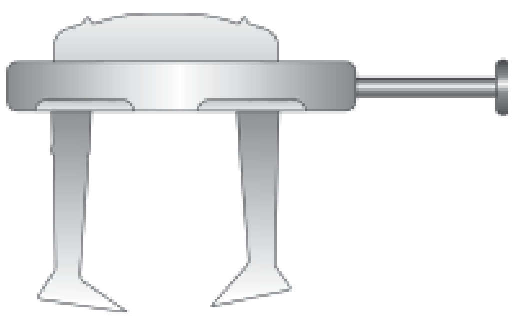


Fig. 23.1: Elliot separator

Traction Method

This is done with mechanical devices which engage the proximal surfaces of the teeth to be separated by means of a holding arm . These are mechanically moved apart which creates separation between the clamped teeth. Examples of traction method are:

Non-interfering true separator (Fig. 23.3): This separator has a advantage of increasing and decreasing the separation even after stabilization and the device is noninterfering. It is indicated when continuous stabilized separation is required.

Ferrier double bow separator (Fig. 23.4): In this device the separation is stabilized through out the operation the advantage of this separation in that the total separation is shared by the contacting tooth and not at the expense of one tooth.

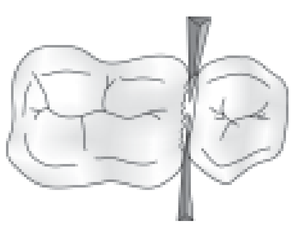


Fig. 23.2: Wood/plastic Wedge

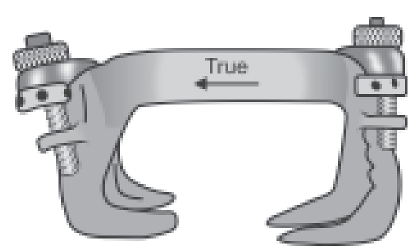


Fig. 23.3: Non-interfering true separator

Fig. 23.4: Ferrier double bow separator

The four arms of the separation are adjusted so that each will hold a corner of the proximal surface of the contacting teeth. The arms should be gingival to contact area but should not impinge on gingivally apply wrench to the labial and lingual to obtain the desired separation then stablize the separation by compound both gingivally and occlusally to the mesial and distal bows.

Slow or Delayed Tooth Movement

This type of separation is indicated when the teeth have drifted and/or tilted considerably.

This separation is achieved over periods of weeks the method of delayed separation are:

a. *Separating wires:* Thin pieces of wires are introduced gingival to the contact and then wrapped around the contact area. The two ends of the wire are twisted together to create separation upto 0.5 mm. Bend the twisted ends in the buccal or lingual embrasure and engaged on the soft tissues. Periodically tighten the wire ends to increase separation the maximum amount of separation is equivalent to thickness of wire.
b. *Oversized temporaries:* Resin temporaries that are oversized mesodistally can be used to achieve slow separation periodically and add resin to contact area to increase the amount of separation which does not 0.5 per visit.
c. *Rubber appliance separation:* A piece of rubber dam correctly lodged in the contact area between two teeth will produce slow separation stretch the piece of dam material and carry it into contact area only a small disk of material should remain in the area whereas the excess on strectching is cut, if the patient can not tolerate the separating force ask the patient to dislodge the piece using dental floss.

   In this method, the amount of separation will be equivalent to thickness of the material.
d. *Orthodontic appliances:* This can bring about tooth movement of any magnitude and in the most effective and predictable method fixed appliance are the preferred as compared to removable appliance, they require less time.

After separation by any delayed separation method use one or more rapid tooth movement method before and during the operative procedure to create space and to compensate for the thickness of the band material if matrix band is used.

24A Dental Casting Alloys

INTRODUCTION

In general, pure metals are too soft to be of use in structural applications and need to be hardened, usually by forming an alloy. It is important that the basic principles of alloys are understood before some particular systems are discussed. In dental technology "precious" and "noble" metals refer to the sp. Group of 8 metallic elements. Gold, silver, platinum, palladium, rohodium, ruthenium, iridium, and osmium. The last 6 of which are the platinum subgroup metals of the precious metals. Noble metal refers to the metal referred to elements low in the customary electro-chemical series, generally below hydrogen as the zero based electrode.

ALLOY: *A specific combination of two or more, metals (or metals and nonmetals) in the solid.* Structurally, the alloy may be a Solid Sollution or a Mixture. Some further terminology is useful:

Components: The starting materials of the alloy

Binery Alloy–two components;

Ternary Alloy–three components;

QuarternaryAlloy–four components.

EFFECTS OBSERVED ON MELTING COMPONENTS TOGETHER

A common method of forming alloys is to melt together the appropriate quantities of the components and to allow the combination to cool. A number of effects may be observed based on the attempted formation of alloys through this approach. These effects depend on the following:

1. Relative atomic sizes of the components
2. Type of lattice of each component
3. Electronic proper ties ('valency')of each component.

Alloys No Mixing in the Liquid

An example is lead (Pb; MP = 328ºC) and aluminum (Al; MP = 661ºC). Attempting to form an alloy by melting together these metals results in a layer of molten *pb* below a layer of molten Al. Thus, these metals have little affinity for each other either in the solid or in the liquid–they are said to be 'immiscible' (insoluble) in the liquid and in the solid. While both metals crystallize with the same lattice (fcc), the disparity arises because of difference in atom size and in electronic properties (AI^3+; pb^2+ & pb^4+).

SOLID SOLUTION

An example is the structure of so-called a-brass. The components are copper (Cu;

MP = 1084ºC) and zinc (Zn; MP = 420 mºC). Both components will mix in all proportions in the liquid. What happens on cooling depends of the proportion of zinc in the alloy. For alloys containing up to 30% (wt) *Zn* (approx), at room temperature, the *Zn* occupies sites in the lattice which would otherwise be occupied by *Cu*. Such a structure is termed a **Substitutional Solid Solution.**

The effect occurs because the components have similar lattices and atom sizes (the latter must not differ by >13% to allow substitutional solid solution), and the same electronic properties (Cu^2+; Zn^2+). It is clear that, under such circumstances, the crystallizing material has difficulty in distinguishing between Cu and Zn atoms. The structure may be further described as a Random Substitutional Solid Solution as there is no pattern to the substitution of Zn for Cu. However, in systems where solid solubility occurs, the effect may not be observed over the complete composition range. There is often observed a **Solubility Limit** of each component in the other, the values of which are usually temperature dependent. A solid solution may also be observed in cases where are components are quite different in terms of lattice, atom size and electronic properties. As might be expected, the mechanism is not the same as that described above and takes place through the component with the smaller atomic size occupying some of the spaces between the atoms of the larger. Such a system is termed an Interstitial Solid Solution since some of the 'interstices' between the larger atoms are occupied. An example is the structure of austenitic stainless steel which is an interstitial solid solution of carbon, C, in face-centered cubic iron, Fe. If there is no pattern to the interstitial occupation (as is usual), the system may be termed a Random Interstitial Solid Solution.

Formation of a Two-Phase Solid

This occurs where there is no affinity, or limited affinity, in the solid, between components (i.e. over the complete composition range, or a limited range). This implies that the mechanisms of solid solution formation are not relevant, in the circumstances.

EUTECTIC SYSTEMS

General

Phase diagrams are often constructed from the observation of cooling curve data. Consider two components which are soluble in all proportions in the liquid but which are insoluble in the solid. The appearance of the cooling curves for the pure components are indicated in the diagram. In principle, the phase diagram can be constructed by recording the cooling curves for different compositions, at suitable intervals, over the entire composition range. In general, addition of one component to the other results in a cooling curve with two inflection, an upper inflection, at temperature T_2, which depends on composition and is depressed from the MP of the major component. There is also a lower plateau T_1, which is independent of composition. In addition, an alloy with a certain particular composition, C_e, features the plateau at T_1, but without the upper temperature T_2. The effects can be explained simply in terms of Collective Properties and depression of the freezing point. Consider two 'components', e.g. water and salt. The salt is freely soluble in water. Cooling a solution of salt in water results in the salt depressing the freezing point of water (below 0 to C), according to the following:

Triangle Tfp=–k fp*m

Triangle Tfp=depression of freezing point.

kfp=molal freezing point depression constant of solvent.

M=molal concentration of all dissolved species. (molality: number of moles of solute per kg solvent; should not be confused with molarity: number of moles solute per litre of solution)

On cooling the solution, it should be observed that the solid which crystallizes is pure ice, as the solubility of salt in ice is negligible. Thus, the water and salt are soluble in solution but insoluble in the solid.

This interpretation can be related to our hypothetical system A-B as follows. The addition of A to B depresses the freezing point of B, which crystallizes out as the pure solid. The addition of B to A has a similar effect on A. Thus, the components are insoluble in the solid to yield a Mechanical Mixture. There is an alloy of a particular composition, CE, for which the freezing points of both components have been depressed to the same value so that this alloy crystallizes at constant temperature. This latter alloy is termed a Eutectic Alloy (Greek; eutectos-easily melted) and an alloy system which features such as alloy is called a Eutectic System.

Binary Eutectic System: Two components which are soluble in all proportions in the melt but insoluble in the solid.

The Eutectic Reaction can be expressed as follows:
Single phase liquid > Two phase solid.

If the temperature data from the cooling curves (T2 and T1) are now plotted vertically against composition (100% component A to 100% component B measured either in term of weight %, or mole %), the metallurgical equilibrium diagram is obtained. Any vertical line on the diagram represents an alloy of a particular fixed composition at various temperatures. The melting points of the pure components are indicated on the 100% composition axes, as appropriate. The upper curve obtained by connecting the melting points of the components with that of the eutectic, via the T^2 temperatures, is called the liquidus. The lower, horizontal, temperature connecting the components is the solidus.

Liquidus: Range of temperatures and compositions above which the alloy system is completely liquid (i.e. molten).

Solidus: Range of temperatures and compositions below which the alloy system is completely solid.

The liquidus and solidus, together with the component axes (100%A and 100%B), from the phase boundaries. The areas defined by the phase boundaries form the phase fields. The phase boundaries, and phase fields, indicate which phase, or phases, are present, in thermal equilibrium, for any composition at any particular temperature.

Peritectics

The peritectic reaction is characterized by a solid and liquid of particular compositions reacting to yield a further solid. Limited solid solubility of two metals can result in a transformation referred as peritactic. The reaction takes place at constant temperature (the peritectic temperature):

$\alpha_p + L_p > \beta$

A generalized peritectic phase diagram is presented. If an alloy of the peritectic composition C_p, is cooled to the peritectic temperature, the relative proportions of a_p and L_p are such that a stoichiometric reacation is possible (in principle) to yield. However, such reactions rarely proceed to completion. If the alloy composition is richer in component A, than the peritectic composition, the equilibrium microstructure at room temperature will be either grains of pure a, or a surrounded by b, depending on the particular starting composition. If the alloy is richer in component B, the equilibrium microstructure at room temperature is b. However, nonequilibrium effects are expected to be an important determinant in such systems.

Desirable Properties of Dental Casting Alloys

The alloys should have the following desirable properties

- Biocompatible, especially they should be nonallergic and should not contain toxic components.
- Good corrosion and tarnish resistant.
- Suitable mechanical properties e.g. – high yield strength, high sag and wear resistance, sufficiently ductile so that it is burnishable.
- Ease of melting, casting, brazing, and polishing.
- Minimal reactivity with mold material.
- Little solidification shrinkage.
- Should be inexpensive.

Historical Perspective

The history of dental casting alloys has been influenced by 3 major factors : technology changes of dental prosthesis, metallurgic advancements, price changes of noble metals.

- The inlay technique described by Taggart in 1907 led to casting of complex inlays such as onlays, crowns, and fixed partial dentures. Because pure gold did not have the physical properties required of these dental restorations, existing jewellery alloys were quickly adopted. These were further strengthened with copper, silver and platinum.
- In 1932, dental materials group at national bureau of standards surveyed the alloys being used and roughly classified the as type I to IV.
- By 1948, the composition of dental noble metal alloys for cast metal restorations had become rather diverse. The tarnishing tendency of original alloys apparently had disappeared. It is now known that is gold alloys, palladium is added to counteract the tarnish potential of silver.
- In late 1950's there was successful veneering of metal substructure with dental porcelain. It was found that adding both platinum and palladium to gold would lower the alloy's coefficient of thermal expansion sufficiently to ensure physical compatibility between porcelain veneer and the metal substructure.
- The base metal removable partial denture alloys were introduced in 1930's. Since then, both Ni-Cr and Co-Cr formulations have become increasingly popular compared with conventional type IV gold alloys. The obvious advantage of base metal alloys being their lighter weight, increased mechanical properties and reduced costs.
- The success of base metal alloys for constructing a RPD framework led to application of some alloys for the fabrication of other restorations. However, intensive research did not start until 1970's, when there was sharp rise in prices of noble alloys.

Classification of Dental Casting Alloys (Tables 24A.1 to 24A.3)

I. Alloy classification of ADA (1984)
   a. High noble metals –> 40% of Au and 60 wt% of noble metals.
   b. Noble metals –> 25% of noble metals.
   c. Predominately base metals – < 25 wt % of noble metals.

II. Classification based on function
   a. All metal restorations.
   b. Metal ceramic.
   c. Removable partial dentures.

III. Dental alloy system based on color and principle element:
- Yellow gold-yellow colored by virtue of gold present.
- White gold-white colored with more than 50% gold content.
- Low gold-yellow colored but with gold content below 60% (42-55%)
- Palladium: white colored with nobility by virtue of palladium present.
- Palladium-silver-white colored with silver the principal alloying element.
- Silver-palladium-white colored with palladium the principal alloying element.

IV. According to another classification –
   A. Precious metal casting alloys
      1. high gold alloys
      2. low gold alloys
      3. palladium-silver alloys
      4. porcelain fused to metal alloys

High gold alloys are further classified as (acc. To ADA SP. No. 5)
1. Type I – Soft
2. Type II – medium
3. Type III – hard
4. Type IV – extra hard

For porcelain fused to metal –
1. Type I – alloys containing more than 90% Au, Pt, and Pd
2. Type II – alloys containing approx. 80% Au, Pt, and Pd.

Table 24A.1: Classification and composition of dental casting alloys

Alloy type	*All metal*	*Metal ceramic*	*RPD*
High noble	Au-Ag-Cu-Pd Metal ceramic alloys	Au-Pt-Pd Au-Pd-Ag(5-12%) Au-Pd-Ag(>12%) Au-Pd	Au-Ag-Cu-Pd
Noble	Ag-Pd-Au-Cu Ag-Pd Metal ceramic	Pd-Au Pd-Au-Ag Pd-Ag Pd-Cu Pd-Co Pd-Ga-Ag	Ag-Pd-Au-Cu Ag-Pd
Base metal	Pure Ti Ti-Al-V Ni-Cr-Mo-Be Ni-Cr-Mo Co-Cr-Mo Co-Cr-W Al bronze	Pure Ti Ti-Al-V Ni-Cr-Mo-Be Ni-Cr-Mo Co-Cr-Mo Co-Cr-W	Pure Ti Ti-Al-V Ni-Cr-Mo-Be Ni-Cr-Mo Co-Cr-Mo Co-Cr-W

3. Type III – palladium silver alloys
   B. Alloys for porcelain fused to metal restorations -

PFM Alloys

Ni	Noble	
Ni-Cr-Be	Pd	Au
Ni-Cr	Pd-Ag	Au-Pt-Pd (21k)
	Pd-Cu	Au-Pd-Ag (13k)
		Au-Pd (13k)

C. Base metal casting alloys -

Base metal alloys

RPD	surgical implants	FPD	
Co-Cr	Co-Cr-Mo	Ni-Cr	Co-Cr
Co-Cr-Ni	Ni-Cr-Co	Be-containing	
Ni-Cr		non Be-containing	

Gold Casting Alloys

Suitably formulated gold alloys are sufficiently hard to used directly in the mouth, in the form of castings. These may encompass inlays, crowns, bridges, clasps, etc. A wax pattern is formed to the required shape, followed by investing and casting of the alloy. Generally, the casting may then be cemented in place after a suitable try-in. Some gold alloy formulations alloy the hardness of the casting to be varied by a heat treatment prior to final cementation. In gold alloys, however, it is of importance that the total base metal content is not sufficiently great that corrosion, and tarnish, resistance is significantly compromized.

Table 24A.2: ISO 1562 Alloys-selected requirements

Type	Composition *gold and PT-group(%wt. MIN)*	Brinell *hardness quenched (Min)(Max)* (Min)	*Hard*	Tensile *strength MPa (MIN)*	*Elongation on 50 m Gauge length (%) quenched(MIN)*	*HARD*	*Fusion temp (^oC)*
I	82	40	-	-	18	-	930
		75					
II	78	70	-	-	12	-	900
		100					
III	78	90	-	-	12	-	900
		140					
IV	75	130	200	620	10	2	870

Table 24A.3: High gold-content alloys-general compositions

Type	Au	Ag	Cu	Pt	Pd	In	Fe	Sn
I	90	7	3	-	-	-	-	-
II	76	12	8	1	12	-	-	-
III	75	10	10	2	21	-	-	-
IV	70	11	12	5	1	-	-	-
PFM Alloys	85	1	-	Pt and Pd 10		1	1	1

The main types of dental casting alloys which contain gold as a major component are as follows:

1. High-content gold alloys.
2. Porcelain fused to metal (PFM) alloys.
3. Medium-content gold alloys

High-Content Gold Alloys (Table 24A.3)

The attraction of high-content gold alloys as casting materials is four-fold:

1. Corrosion resistant
2. Biocompatible
3. Easily melted and cast
4. Full compensation possible for shrinkage on cooling.

Many of the materials are formulated to conform with ISO standard 1562-dental casting gold alloys, and it is useful to discuss the materials in this context. This International standards recognizes four type of high-content gold alloy:

Type I: soft (ordinarily used for dental restorations and appliances which are subject to very slight stress and where burnishing is required.

Type II: medium (ordinary used for dental resthorations and appliances which are subject to moderate stress: 3/4 crowns, abutments, pontics, full crowns and saddles).

Type III: hard (ordinary used for dental resthorations and appliances which are subject to high stress: 3/4 thin crowns, thin cast backings, abutments, pontics, full crowns and saddles).

Type IV: extra hard (ordinary used for dental restorations and appliances which are thin in cross-section and subject to very high stress: saddles, bars, clasps, crowns, thimbles and unit castings).

Traditional terminology described types I-III as inlay golds (soft-medium-hard), and Type IV as partial denture gold, the latter based on the previous use of this material as the framework for a partial denture.

An important requirement of ISO 1562 is that of composition. The composition of these alloys must be at least 75% (wt) gold and metals of the platinum group (platinum, palladium, iridium, rhodium, ruthenium, osmium), in the case of type IV, with correspondingly higher values for the other types. This requirement is to ensure that the materials do not tarnish, or corrode, in the mouth. The more important alloying elements are silver (Ag), copper (Cu), platinum (Pt) and palladium (Pd). Iridium (Ir) may be present as a grain refining agent (0.005% wt, approx). In addition to a solution hardening effect other important effects of these additions are as follows:

Silver: Reduces the melting range of the alloy.

Palladium: May replace platinum.

Copper and Platinum: Order hardening effects [for Cu content of > 8% (wt) approx].

The order hardening process with Cu can be understood with respect to the Au-Cu phase diagram. The diagram is consistent with total solid solubility, which occurs via a substitutional, mechanism. Two further single phase fields are present below the solidus, which represent 'compounds' of variable stoichiometery, Au-Cu and $Au\text{-}Cu^3$. Conditions which favour the formation of Au-Cu (A suitable composition range, and a temperature < 450 ºC, approx) result in the migration of Cu and Au atoms to preferred sites in the solid. The effect is that the random substitutional solid solution gradually breaks down and is replaced (in part) by the lattice, and unit cell, appropriate to Au-Cu. As both of these parameters are different from those of the host solid solution, the effect is to introduce dislocations into the casting. These dislocations hinder plastic deformation and the material is further hardened by this mechanism – Order hardening. Thus, rapid cooling in water (quenching) to room temperature, from a temperature just below the solidus, retains the casting in the 'soft' condition (solid solution hardening only), as sufficient time is not available for atoms to migrate in the solid to form AuCu (order hardening). In this, relatively soft, condition the fit of the casting can be checked, and burnishing of the edges carried out, if required. Before cementation in the mouth, the casting is re-heated to 450 degree C for 10 mins, to allow the ordering effect to occur, and allowed to air cool. If required, the casting may be softened again by re-heating to 700 degree C. In practice, the Cu content of the alloy needs to be > 8% (wt) to allow effective order hardening (i.e. Types III & IV).

Heat Treatment Au-Cu: Hardening

1. Heat to 450ºC
2. Hold for 10 mins
3. Air-cool

Ideally, before the alloy is given an age-hardening treatment, it should be subjected to softening heat treatment to relieve all strain hardening, if it is present, and to start the hardening treatment with the alloy as a disordered solid solution. Otherwise, there would not be a proper control of hardening, process because the increase in strength, proportional limit, and hardness and reduction in ductility are controlled by the amount of solid-state transformations allowed. The transformation, in turn, are controlled by the temperature and the time of age hardening treatment.

Softening

1. Heat to 700ºC for 10 mins
2. Water quench

During this period, all intermediate phase are presumably changed to a disordered solid solution and the rapid quenching prevents ordering from occurring during cooling. The tensile strength, proportional limit and hardness are reduced but ductility is increased.

PC Moon et al in 1976 studied the burnishability of dental casting alloys. It was seen that all gold alloys have comparatively lower burnishability no. where as the cast alloys are almost impossible to burnish.

Porcelain Fused to Metal (PFM) Gold Alloys

The aesthetic appeal of porcelain, coupled with relative inertness in the mouth, made for a desirable restorative material. However, dental porcelain is brittle and will only tolerate relatively small strains (about 0.1%) before failure. The utility of dental porcelain, as a restorative, can be extended in the 'porcelain fused to metal' technique. A thin layer of dental porcelain is fused to a metal casting which then presents an aesthetic crown, bridge, etc. The technique can also be termed 'enamelling'. However, neither the type of porcelain used for jacket crowns, nor the gold casting alloys discussed, are suitable for use in this technique. The coefficient of thermal expansion of the porcelain must be suitably matched with that of the alloy and the melting range of the alloy must be raised sufficiently above the fusion temperature of the porcelain for a successful enamelling operation.

Suitably-formulated high-content gold alloys are available for the technique and a typical alloy composition is presented. It is important that the alloy does not contain components which form colored oxides, at the interface, or which give rise to color effects within the porcelain. Copper is not used in the porcelain-bonding gold alloys.

There are two bonding mechanisms possible whereby dental porcelain may be retained to the structure of a metal casting:

1. Mechanical interaction
2. Adhesion (chemical bonding)

Alloy becomes heat-hardened during the porcelain firing protocol:

Slow heating to 980 ºC
Hold for 2 minutes
Slow cool
(repeat for core/dentine/enamel)

Heat treatment involves an order hardening mechanism (Fe-Pt and Pt-Au). The effects of order hardening may be reversed by heating to 900º C and quenching.

MEDIUM-CONTENT GOLD CASTING ALLOYS

These represent a range of alloys which parallel the high-content gold systems, but with a total gold and platinum group metal content of between 25% and 75% (wt). A similar classification, Types I-IV, is relevant and some materials are suitable for heat treatment. The reduced content of noble metals may make such materials more prone to tarnish and corrosion and the biocompatibility of materials should be reported.

SILVER-PALLADIUM CASTING ALLOYS (WHITE GOLD)

Silver and palladium feature full solid solubility. While palladium (Pd) features a strong affinity for hydrogen gas, it is one of the platinum group metals and is relatively high melting (MP = 1552ºC). Silver (Ag) is lower melting (MP = 962ºC), making it more suitable as the basis of a dental casting alloy, but tarnishes easily in the presence of hydrogen sulphide. Silver can be protected from tarnishing through the addition of palladium, the degree of protection determined by the quantity of palladium present. The Ag-Pg dental casting alloys (also referred to as White Gold) are, essentially, ternary Ag-Pd-Cu systems and may be single-phase, or multi-phase. The alloys can be heat treated to increase surface hardness (precipitation hardening). A generalized composition is as follows:

	%(wt)	
Ag:	45	host material
Pd:	25	solid solution hardening: tarnish, protection
Cu:	15	precipitation hardening
Au:	14	solid solution hardening
Zn:	1	protection of Cu on melting

Accounts are at variance with respect to the suitability of Ag-Pd alloys for dental precision castings. However, it would appear that, with general attention to detail and careful melting of the alloy in an inert gas atmosphere, accurate castings are possible not with standing the relatively high melting range of the materials and low density. The materials will accept porcelain but it should be borne in mind that the affinity of porcelain for Ag is relatively high an effect which may impact a greenish tint to the ceramic. A suitable coating material for the alloy may be required.

The alloys become precipitation (age) hardened during the porcelain firing cycle.

HIGH-CONTENT PALLADIUM CASTING ALLOYS

Recently, alloys featuring a high palladium content have been developed for the porcelain fused to metal technique. Palladium content is usually in the range 75-78% (wt) and the alloys based on one of the ternary systems; Pd-Cu-Ga, Pd-Co-Ga or Pd-Ag-Sn.

The materials should be melted using an induction technique and in an inert gas atmosphere. Values for the 0.1% proof stress and surface hardness are relatively high, but some physical properties appear to be sensitive to trace concentrations of carbon (> 60 ppm, approx). In this respect, melting these alloys in a carbon/graphite crucible may be contraindicated, with clay or aluminum oxide crucibles to be preferred. Any other sources of carbon uptake should be identified and monitored.

BASE METAL CASTING ALLOYS

Since the development of Co-Cr alloys for cast dental appliances in 1928 and the subsequent introduction of Ni-Cr and Ni-Co-Cr alloys in later years, base metal alloys have demonstrated widespread acceptance. Compared with type IV gold alloys, these alloys have greater stiffness, higher hardness, lower cost, low density and comparable clinical resistance to tarnish and corrosion.

COBALT-CHROMIUM CASTING ALLOYS

These alloys are prone to oxidation on melting and the castings produced are rather hard and brittle. The high melting temperature requires the use of a phosphate-bonded investment and the shrinkage, on cooling (1.9% linear), is such that dimensional accuracy is difficult to achieve. Thus, the alloys are unsuitable for precision castings, such as crown and bride components, and over-oxidation, on heating, also makes them unsuitable for the fusion of porcelain to the surface. However, the materials are corrosion resistant and well tolerated in the mouth. Typical application of Co-Cr-Mo alloys in dentistry is with respect to the framework of partial dentures.

A generalized composition is as follows:

	%(wt)	
Ag:	45	host material
Co;	65	host lattice (hep)
Cr:	25	corrosion resistance; forms a passive layer of Cr_2O_3 on the surface
Mo:	5	grain refining agent
C:	0.2-0.35	main hardening component
Ni:	bal	but caution regarding Ni hypersensitivity

Co-Cr alloys are essentially metastable face-centered cubic (fcc) systems with carbides present at the grain boundaries and interdentritically. The melting range (1250-1450ºC) is beyond the capacity of the gas-air torch, and these alloys are either melted by flameless electromagnetic induction or by oxy-acetylene flame. Quenching the casting would result in a fine precipitate of carbides forming within the grains and would yield an inconveniently hard surface. On the other hand, slow cooling results in the preferential deposition of carbides at the grain boundaries, where a continuous layer may be formed. This results in a brittle casting. A compromise is bench-cooling which results in elements of both effects being present but with discontinuous carbide formation at the grain boundaries.

The value of Young's Modulus for these alloys is approximately three times that of the gold alloys. This increased rigidity is useful in that thinner sections will feature the same load-deflection relationship as for the gold alloys (e.g. connectors of a partial denture) but it is unfortunate that the effect is accompanied by a reduced elastic limit (530 MPa, approx). The increased modulus, in association with the reduced elastic limit, makes the design of features such as clasps more problematic. The difficulty is that the arms of a clasp must be displaced elastically, which requires a stress less than the elastic limit. Because of the increased modulus for Co-Cr, a greater stress is required for a given deflection (strain), and this stress may exceed the elastic limit of the material.

NICKEL-CHROMIUM CASTING ALLOYS

The Ni-Cr alloys were investigated for dental applications in an attempt to overcome some of the limitations of cast Co-Cr, i.e. the minimal ductility, high cooling shrinkage, and tendency towards over-oxidation. Industrially, these alloys are known as Nimonics and find applications in jet-engine technology. A generalized composition for the dental casting alloys is as follows:

	% (wt)
Ni	68-80
Cr	10-25
Mo	0-13
W	0-7
Mn	0-6
Be	0-2
C	0.1-0.2

with other minor components such as Al, Ti, Co (all hardening agents), and B and Si (deoxidisers on melting).

The alloys are suitable for the porcelain fused to metal technique. The Be (beryllium) –containing alloys present a toxic hazard in the laboratory, through the possible inhalation of dust from the grinding procedures. Suitable precautions must be taken.

The alloys crystallize with a face-centered cubic lattice, and the castings feature a relatively large grain size with a marked dendritic grain structure. The materials are, typically, more ductile than cast Co-Cr but quite a variation is possible in some physical properties, depending on particular compositions and heat-treatment. Hardening mechanisms involve the precipitation of a further phase, or phases, within the material, particularly the so-called 'γ1 phase' (gamma prime phase–$(Ni\text{-}Co)_3(Al\text{-}Ti)$). In addition, carbides may be formed interdendritically. The values of Young's Modulus and surface hardness are somewhat less than the corresponding values for Co-Cr. Setting contraction is of the order of 1.5% (linear), and the alloys are usually melted by electromagnetic induction and cast into a phosphate-bonded investment.

Due to the lower melting range, greater accuracy is possible with Ni-Cr than Co-Cr and crown and bridge components can be successfully cast. Because of the dendritic crystallization, the Ni-Cr alloys are extensively used in the 'resin-bonded bridge' technique, with grit blasting of the surface for retention to acid-etched enamel. The Ni-Cr materials are not as inert as Co-Cr.

HEAT TREATMENT OF BASE METAL ALLOYS

The early base metal alloys used for partial denture prosthesis were primarily Co-Cr and were relatively simple. Heat treatment of these alloys up to 1 hr at 1000ºC did not change their mechanical properties appreciably. Base metal alloys available today are more complex. Presently, complex Co-Cr alloys as well as Ni-Cr and Fe-Cr alloys are used for this purpose. Studied have shown that heat treatment of Co-based alloys reduces both the yield strength and elongation. For this reason some soldering and welding must be performed on these partial dentures, the lowest possible temperature should be used with the shortest possible time of heating to the elevated temperature.

The coarse grain size are interdendritic carbide and meu phases present in the cast Co-Cr-Mo limit the strength and ductility of the as cast alloy. Because the interdendritic phases are associated with reduced ductility and reduced corrosion resistance, cast Co-Cr-Mo is typically solution annealed at approx. 1225ºC. If the treatment and chemical composition is controlled, such a thermal treatment results transformation of meu to M23C6 and the partial dissolution of the M23C6 phase, leading to increased yield strength and ductility.

Slow cooling to temperatures below those at which incipient melting occurs enhances ductility. A reduction in the carbon content also enhances ductility. In general, excess grain-boundary carbide decreases ductility, whereas structures with carbide free grain boundaries are characterized by markedly reduced yield and tensile strengths.

BONDING ALLOYS TO TOOTH MATERIAL

The bonding of alloys to tooth material involving resin cements. A further technique, Silicoating tin is briefly given here–

SILICOATING TIN

This technique involves the introduction of a thin 'SiOx-C' layer onto the surface of the alloy. The Si-containing moieties can be utilized for bonding to resin via a silane bonding agent. The general technique involves grit-blasting the fitting surface; coating the surface in the oxidizing portion of a tetraethoxysilane-propane-oxygen flame ('flame spraying'), followed by application of the silane bonding agent.

BIOCOMPATIBILITY OF DENTAL CASTING ALLOYS

Most cast dental restorations are made from alloys or commercially pure titanium (Cp-Ti). It has been documented *in vitro* and *in vivo* that metallic dental devices release metal ions, mainly due to corrosion. Those metallic components may be locally and systemically distributed and could play a role in the etiology of oral and systemic pathological conditions. The quality and quantity of the released cations depend upon the type of alloy and various corrosion parameters. No general correlation has been observed between alloy nobility and corrosion. However, it has been documented that some Ni-based alloys, such as beryllium containing Ni alloys, exhibit increased corrosion, specifically at low pH. Further, micro-particles are abraded from metallic restorations due to wear. In sufficient quantities, released metal ions-particularly Cu, Ni, Be, and abraded microparticles can also induce inflammation of the adjacent periodontal tissues and the oral mucosa. While there is also some *in vitro* evidence that the immune response can be altered by various metal ions, the role of these ions in oral inflammatory diseases such as gingivitis and periodontitis is unknown. Allergic reactions due to metallic dental restorations have been documented. Ni has especially been identified as being highly allergenic. Interestingly, from 34 to 65.5% of the patients who are allergic to Ni are also allergic to Pd. Further, Pd allergy always occurs with Ni sensitivity. In contrast, no study has been published which supports the hypothesis that dental metallic materials are mutagenic/genotoxid or might be a carcinogenic hazard to man. Taken together, very contradictory data have been documented regarding the local and systemic effects of dental casting alloys and metallic ions released from them. Therefore, it is of critical importance to elucidate the release of cations from metallic dental restorations in the oral environment and to determine the biological interactions of released metal components with oral and systemic tissues.

DIFFERENCE BETWEEN ALLERGY AND TOXIC REACTIONS

It is often difficult to determine whether an inflammatory response is to a metal ion is mediated by as allergic mechanism or a toxic mechanism or some combination of both. Classically allergic responses are characterized by dose independence. Thus low dose will not cause inflammation through toxicity, would cause by inflammation by activating immune cells. Metal ions may alter or disrupt normal immune pathways, which then cause an inflammatory response. This type of response may be viewed as toxic response because it does not involve the recognition of a specific metal protein complex.

More recently the concept has been advanced that allergic reactions to metal ions may also have a threshold below which no reaction occurs. Only when this threshold is exceeded dose, the dose independence applies. Patch tests are usually helpful.

Systemic Toxicity–there is little evidence that elements released from casting alloys contribute significantly to the systemic presence of elements in the body. However, Ni released from Ni based alloys may approach 400 micrograms/day if subjected to an acidic environment. Also if the Cr content is less that 20% the Ni release increases.

Route by which an element gains access inside the body is critical to its biologic effects. A good example can be palladium ions. If administered orally to mice, they have lethal dose of LD50, lethal dose that will kill 50% of the animal of 1000 mg/kg. If administered peritoneum the LD50 is 87 mg/kg.

Wataha JC et al in 2002 studied the **Effect of toothbrushing on the toxicity of casting alloys.**

The biological properties of casting alloys have been assessed largely under passive conditions. The effect of common intraoral stresses such as brushing, toothpastes, and low pH on alloy toxicity are not known. The purpose was to assess the toxicity of 5 types of casting alloys commonly used in prosthodontics after toothbrushing, brushing in an acidic environment, or brushing with toothpaste. These toxicities were compared with those observed without any brushing : Au-Pt, Au-Pd, Pd-Cu-Ga, Ni-Cr-Be, and Ni-Cr (no Be). Alloys were brushed with either saline at pH >, saline at pH 4 (acidified with dodium lactate), or saline with 1:7 (wt/wt) toothpaste. After the brushing regimen, the cytotoxicity of the alloys was assessed in a standard *in vitro* test. Cytotoxicities of the alloys after different brushing treatments were compared with unbrushed (control) specimens. Brushing at pH 7 significantly increased the toxicity of the Pd-Cu-Ga alloy (15% to 20% over unbrushed specimens). Brushing at pH 4 increased the toxicity of the Au-Pt and Au-Pd alloys by 30% and the Pd-Cu-Ga alloy by > 40%. The Ni-based alloys were not affected by acid. After being brushed with toothpaste, both Ni-based alloys were significantly more toxic, but Ni-Cr-Be was the worst, increasing more than 60% in toxicity over the controls. The toxicity of the Au-Pd alloy also increased significantly (15%). Brushing dental casting alloys may increase their cytotoxicity *in vitro*, but the increase depends heavily on the alloy type and brushing condition.

Wataha JC et al in 1996 studied the Biological effects of palladium and risk of using palladium in dental casting alloys.

In an ionic form and at sufficiently high concentrations, palladium has toxic and allergic effects on biological systems. Palladium allergy almost always occurs in individuals who are sensitive to nickel. The carcinogenic potential of the palladium ion is still unclear. Although there is some evidence that it is capable of acting as a amalgam however, there are no well documented cases of adverse biological reactions to palladium in the metallic state. Furthermore, in spite of the potential adverse biological effects of palladium ions, the risk of using palladium in dental casting alloys appears to be extremely low because of the low dissolution rate of palladium ions from these alloys.

Huang HH in 2002 studied the effect of chemical composition on the corrosion behavior of Ni-Cr-Mo dental casting alloys.

The objective of this investigation was to study the compositional influence on the corrosion behavior of Ni-Cr-Mo dental casting alloys in acidic artificial saliva. The results show that the corrosion resistance of the Ni-Cr-Mo casting alloys investigated is associated with the formation of passive film containing $Ni(OH)^2$, NiO, Cr^2O^3, and MoO^3, on the surface. The pitting potential and passive range, respectively, were statistically different among the different Ni-Cr-Mo alloys. The Ni-Cr-Mo alloys with higher Cr (approximately 21%) and Mo (approximately 8%) contents had a much larger passive range in the polarization curve and were immune to pitting corrosion due to the presence of high Cr (maximum approximately 31-35%) and Mo (maximum approximately 12%) contents in the surface passive film. The presence of Ti lower than 4% in the Ni-Cr-Mo casting alloy had no effect on corrosion resistance. A pitting resistance equivalent (PRE) of about 49 could provided the Ni-Cr-Mo alloy with a good pitting corrosion resistance.

Nelson SK et al. in 2002 studied *in vitro* TNF-alpha release from THP-1 monocytes in response to dental casting alloys exposed to lipopolysaccharide.

Studies have found that lipopolysaccharide (LPS) attaches to and is eluted from dental alloys, but the biologic effects of LPS are not known. This study evaluated the ability of dental casting alloys pre-exposed to LPS to activate human monocytes with and without subsequent elution of the LPS.

Conclusion

In this *in vitro* system as in past studies, LPS appeared to adhere to and elute from the alloys. Monocytes were activated initially but not after elution into PBS for 120 hours. Alloy conditioning solutions may also have an artifactual effect on cytokine release.

Tufekci E et al in 2002 studied inductively coupled plasma-mass spectroscopy measurements of elemental release from 2 high-palladium dental casting alloys into a corrosion testing medium.

The biocompatibility of high-palladium alloy restorations has been of some concern due to the release of palladium into the oral environment and sensitivity reactions in patients. This study measured the *in vitro* elemental release from a Pd-Cu-Ga alloy and a Pd-Ga alloy into a corrosion testing medium.

Relative proportions of the elements in the solutions were consistent with the release of palladium and breakdown of microstructural phases found in the alloys. The results suggest that there may be a lower risk of adverse biological reactions with the Pd-Ga alloy than with the Pd-Cu-Ga alloy tested.

David A Newitter et al in 1983 studied and verified the nature of dental casting alloys.

A geologic field test was modified for determining the presence of goid in dental alloys. This test gave positive evidence for the presence of gold in most of the alloys samples tested containing 59% or more gold. It is recommended that dentists use this procedure for color comparison of the casting alloys.

In any of the technical considerations of the procedure are dependent upon knowledge of the casting alloy itself. There have been enormous advances in the development of dental casting alloys. Not only the number of alloys have increased but also new systems have been developed in recent years. as far as the biocompatibility of the alloys are concerned testing should always include corrosion testing for the release of elements and if possible, basic biocompatibility tests to determine whether the element release is biologically relevant.

24B Dental Casting Procedures

INTRODUCTION

In 1907, WH Taggart, introduced the casting procedure by cast wax technique, which is now a common practice.

The casting method consists is forming the wax pattern, surrounding it with investment material and later heating the mold to remove the wax before casting the melted metal into the model.

The purpose of a dental casting is to provide a metallic replacement for missing tooth structure. The casting should be as, accurate as possible, so technical procedures and proper handling of materials is very important.

Various steps is casting process are –

- Tooth preparation
- Making impression of prepared tooth
- Die preparation
- Wax pattern formation
- Sprue former
- Placement of ring lines in casting ring
- Investing the pattern
- Wax elimination the heating
- Casting
- Quenching
- Recovery of casting
- Sand blasting
- Pickling
- Polishing

After the tooth has been prepared, its impression is taken and die is prepared either from stone or impression is electroformed. This is followed by making of wax pattern.

Formation of Wax Pattern (Figs 24B.1A and B)

Wax pattern can be prepared by–

- Direct method
- Indirect method

Direct Wax Patterns

In this the wax pattern is prepared in the patient's mouth. The type I wax for a direct wax pattern must be heated sufficiently to have adequate flow and plasticity under compression to reproduce all details of cavity walls. At the same time, overheating of wax should be avoided because of possible tissue damage and discomfort to the patient, as well as difficulty encountered is compression of overheated wax.

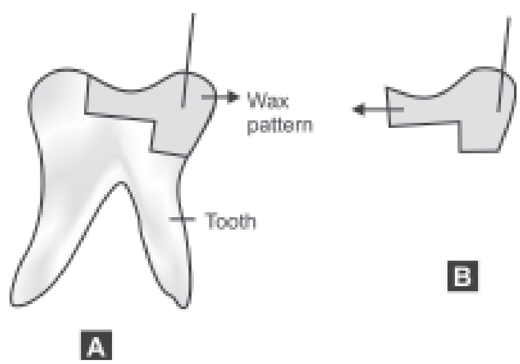


Fig. 24B.1: Wax pattern formation

When C wax is heated to the proper working temperature of approx. 50º-52ºC for a short period of time, the previously induced stresses from manufacturing and handling tends to be dissipated. It is desirable to have such a stress free piece of wax at the proper consistency, so that the pattern when formed under pressure will be relatively stress free. Thus, minimum distortion will result when the pattern is subsequently removed from the tooth. Since wax has a rather low thermal conductivity, the reduction from the working temperature to mouth temperature occurs slowly, and ample time for cooling should be allowed. The decrease in temperature of the wax to mouth temperature results in a contraction. This contraction, to some degree, is compensated for when the pattern is formed under pressure until the decrease in mouth temperature is completed. The pattern is carved in the mouth only.

Indirect Wax Patterns

In this method, an impression of cavity prepared is taken and a die is formed on which the pattern is prepared.

In the method, type II wax is used.

The converence provided by the indirect method makes the property of flow less critical, as the pattern to be removed from the die at a lower temperature and with much greater ease.

When adapting the wax to die, it is necessary to use some lubricant to permit release of wax pattern from the die. An excess of separator should be avoided, since it leads to inaccuracies in the wax pattern and poor surface of cast alloy. The wax may be adapted to the die either by flowing of small melted increments from a spatula to build up the desired contour or by the copression method.

Carving of indirect wax pattern should be accomplished with a warm instrument as it minimizes the stresses exerted on wax.

Spruing the Pattern (Fig. 24B.2)

The purpose of spruing the wax pattern is fowfold:

- To form a mount for wax pattern
- To create a channel for wax elimination during burnout
- To form a channel for molten alloy ingress
- To compensate for alloy shrinkage during solidification.

The purpose of a sprue former, or spine pin, is to provide a channel through which molten metal can reach the mold is an invested ring after the wax has been eliminated.

The diameter and length of the sprue former depend to a large extent on the type and size of pattern, the type of casting machine to be used, and the dimensions of the flask or ring is which the casting is to be made. Prefabricated spine forms are available is a wide range of gauges or diameters.

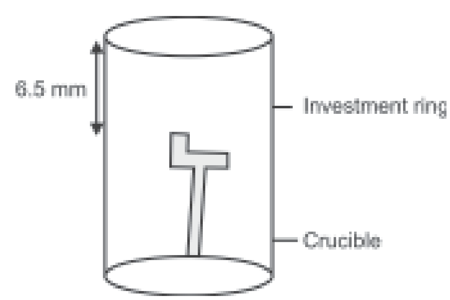


Fig. 24B.2: Spruing of the pattern

When selecting the sprue former, following general principles should be considered.

- Select the gauge sprue former with a diameter that is approximately the same size as the thickest area of the wax pattern.
- If possible, sprue former should be attached to the portion of the pattern with the largest cross-sectional areas. Also sprue former orientation should minimize the risk of metal flow onto flat areas of investment or small areas such as line angles.
- The length of spine former should be long enough to properly position the pattern is the casting ring with 6 mm of the trailing end and yet short enough so that molten alloy does onto solidify before it fills the mold.
- The type of spine former selected, influences the burnout technique used. Wax spine formers are more common than plastic.
- Patterns may be sprued either directly or indirectly.
- Reservoirs should be added to spring network to prevent localized shrinkage porosity.
- Sprue former connection to the wax pattern is generally flared for higher density gold alloys but is often restricted for lower density alloys. Flaring of spine former may act is much the same ways as a reservoir, facilitating the entry of fluid alloy into the pattern area.
- Position of spine former attachment is a matter of individual adjustment, based on shape and form of wax pattern.
- The ideal area for the spine former is the point of greatest bulk is the pattern to avoid distorting this areas of wax during attachment to the pattern and to permit a smooth flow of the alloy.
- Spine former should be directed away from any thin or delicate parts of the pattern, because the molter metal may abrade or fracture investment is the area and result is a casting failure.
- It should not be attachment at a right angle to a broad flat surface. When it is sprued at a 45^{o} angle to proximal area, a satisfactory casting is obtained.
- Length of spine former depends on length of the casting ring. It should be adjusted so that top of wax pattern is within 6 mm of the open end of ring for gypsum bonded investments (if it is too short, then gases cannot be adequately verted to permit molter alloy to fill the ring completely). With higher strength phosphate bonded investments, it may be possible to position it within 3 to 4 mm of the top of the investment. For reproducibility of casting accuracy, the pattern should be placed as close to center of ring as possible.

Investing the Pattern

The wax pattern should be cleared of any debris, grease or oils. A commercial wax pattern clearer or a diluted synthesis detergent is used. Any excess liquid is states off and the pattern is left to air dry while the investment is being prepared. This film of clearser left on the pattern reduces the surface tension of the wax and permits better "wetting" of the investment to ensure complete coverage of the intricate portions of the pattern.

There are two different methods of investing

- Hand investing
- Vacuum investing

Advantages of Vacuum Investing

- Removes air bubbles created during mixing
- Evacuates any potentially harmful gases produced by chemical reaction of high heat investments
- Porosity is reduced
- Smoother casting
- Better detail reproduction
- Increased tensile strength of investment
- 95% castings are module free

Pattern is pointed with this layer of investment, casting ring is positioned on crucible former and remainder of investment is vibrated slowly into the ring.

If hygroscopic technique is employed, the filled casting ring is immediately placed in a 37ºC water bath with the crucible former side down.

For thermal expansion or high heat tech., the invested ring is allowed to bench set undisturbed.

The sprue former should be attached to the wax pattern with the pattern on master die, provided the pattern can be removed directly in line with its path of withdrawal from the die. Any motion that might distort the wax pattern should be avoided during removal.

Casting Ring Liners

A ring liner is placed inside the casting ring. Its functions are –

- allows for mould expansion
- when the ring is transferred from the furnace to the casting machine it reduces loss of heat as it is a thermal insulator
- permits easy separation of the investment from the ring after the casting is over.

Types

- Asbestos – not used because carcinogenic
- Nonasbestor liners
  Fibrous ceramic aluminous silicate
  Cellulose (paper)
  Ceraic cellulose combination

It may used dry or wet.

- It allows greater normal setting expansion is investment
- Also absorbed water causes a semi-hygroscopic expansion
  - Thickness of liner should not be less than approx..1 mm
  - Placing the liner somewhat short (3.25 mm) of the ends of ring tends to produce a more uniform expansion, thus there is less chance for distortion of the wax pattern and the mold.

Various Investing Technique Used are:

1. Hygroscopic low heat technique
2. High heat thermal expansion technique
3. Controlled water added technique
4. Phosphate bonded technique.

Hygroscopic Low Heat (Water Immersion Technique—Figs 24B.3A to E)

- Investments made from this technique are stronger and thus a metal ring is not necessary instead rubber ring is used.
- Maximum hygroscopic expansion is obtained by immersing the invested pattern and rubber ring, allowing the investment to set under water.
- In this case most compensatory expansion is hygroscopic (1.5%)
- After investment has set, rubber ring is removed from mold and mold is placed directly into 480ºC over for 30-45 minutes.
- With water immersion investment, one can expect as overall expansion of 2.10%.

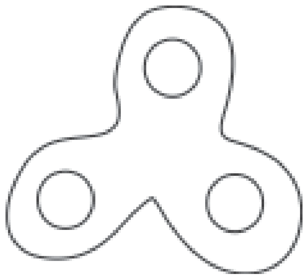


Fig. 24B.3A

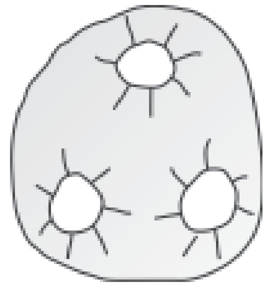


Fig. 24B.3B

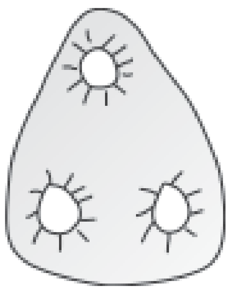


Fig. 24B.3C

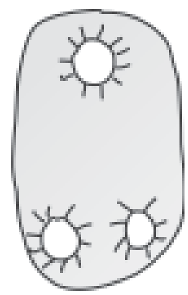


Fig. 24B.3D

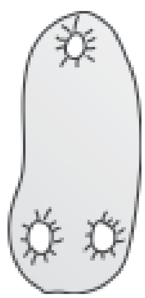


Fig. 24B.3E

Figs 24B.3A to E: Hygroscopic low heat (water Immersion Technique)

High Heat Technique

– It employs cristobalite (high expansion form of silica) investment materials.
– Investment is mixed according to manufacturers instructions and allowed to set for at least 45 minutes and not more than 60 minutes, mold is placed is a 200ºC over for 20-30 minutes to bur out the wax pattern.
– Temperature of mold is further elevated by transferring mold to a second over and holding at 700ºC for no longer than 20-30 minutes to obtain maximum thermal expansion of 1.25%.
– It is weak in nature and so metal ring is required.
– Ring liner should be used to increase setting expansion (0.35%).
– Most of compensation is TE that takes place after wax pattern is eliminated from mold.

Controlled Water Added Technique (Low Heat Hygroscopic)

– It is similar to water immersion technique, except that instead of allowing the invested pattern to set under water, a metal collar is placed on top of rubber ring to act as a reservoir for the predetermined amount of water to be added.

- Water is added top of investment and not mixed with it.
- After 45 min, collar and rubber ring are removed and mold pattern is placed is 480ºC over.
- Both high heat and water immersion type of investments offer little flexibility because each has a predefined expansion potential.

Phosphate Bonded Investment

- Supplied as powder containing silica, primary aluminum phosphate and magnesiam oxide.

  Setting reaction in aqueous solution is

$$NH_4H_2PO_4 + MgO -> NH_4MgPO_4 + H_2O$$

Expansion is adjusted by varying amount of silicasol liquid used is mixing and by employing hygroscopic and high heat expansion methods.

Casting Procedure

Once the investment has set for an appropriate period–approximately 1 hr. it is ready for burnout.

The crucible former and any metal spine former are carefully removed. Any debris from the ingate area (founded opening at end of ring) is cleared with a camel-hair brush. If the burnout procedure does not immediately follow the investing procedure, the invested ring is placed in a humidor at 100% humidity.

Invested rings are placed in a room temperature furnace and heated to prescribed maximum temperature for gypsum bonded investments, temperature can be either 468ºC for hygroscopic techniques or 650°C for thermal expansion technique. With phosphate bonded investments, the maximum temperature setting temperature may range from 700ºC to 870ºC, depending on the type of alloy selected.

After the casting temperature has been reached, casting should be made immediately. Maintaining a high temperature for any considerable length of time may result in a sulfur contamination of the casting and also in a rough surface on the casting because of disintegration of investment.

Casting Machines

Alloys are melted in one of following ways: depending on the available types of casting machines:

- Alloy is melted in a separate crucible by a torch flame and the metal is cast into the mold by centrifugal force.
- Alloy is melted electrically by a resistance or induction furnace, then cast into the mold centrifugal by motor or sping action.
- Alloy is melted in first two ways, but it is cast by air pressure, a vacuum or both.

Methods of Alloy Melting

Torch	*Electrical*
1. Gas/air	1. Resistance
2. Gas/oxygen	2. Induction
3. Air/acetylene	3. Electric arc
4. Oxygen/acetylene	4. They are costlier

Centrifugal Casting Machine (Figs 24B.4A and B)

Casting machine spring is first wound from 2 to 5 turns. Metal is melted by a torch flame in a glazed ceramic crucible attached to the "broken arm" of the casting machine. The broken arm feature accelerates the initial rotational speed of crucible and casting ring, thus increasing the linear speed of the liquid casting alloy as it moves into and through the mold. Once the metal has reached the casting temperature and the heated casting ring is position, the machine is released and the spring triggers the rotational motion.

Electrical Resistance Heated Casting Machine

In this there is an automatic melting of the metal in a graphite crucible within a furnace rather than by torch.

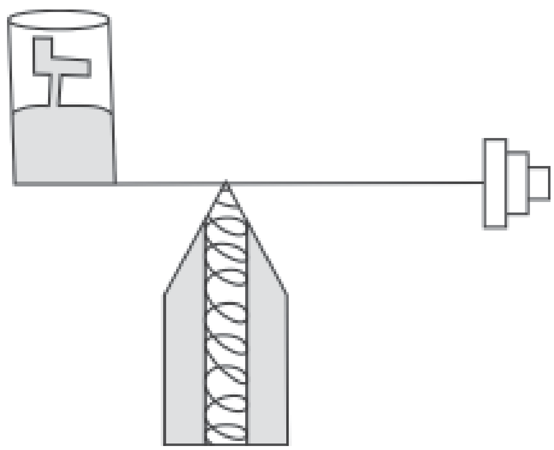


Fig. 24B.4A: Centrifugal casting machine

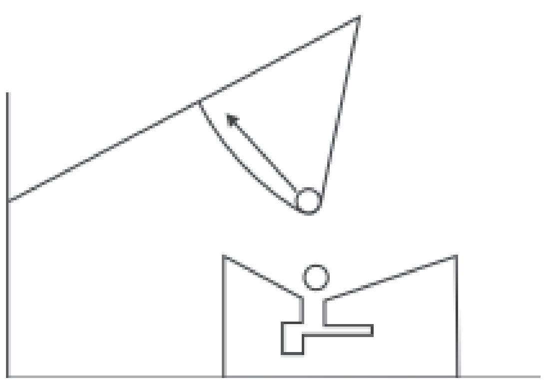


Fig. 24B.4B: Air pressure

Advantages

- Especially for alloys like those used for metal ceramic restorations, which are alloyed with base metals in trace amounts that tend to oxidize on over-heating.
- Crucible in furnace is located flush against casting ring. So, the metal button remain molten.

  Slightly longer, again ensuring that solidification progresses completely from tip of casting to button surface.

  Carbon crucible should not be used in the melting of high palladium or palladium silver alloys, where the temperature exceeds 1504°C or with nickel-chromium or cobalt-chromium base metal alloys.

Induction Melting Machine

With this unit, the metal is melted by as induction field that develops within a crucible surrounded by water cooled metal tubing. Once the metal reaches the casting temperature, it is forced into mould by air pressure, vacuum or both at the other end of ring.

There is little practical difference in the properties or accuracy of castings made with any of the 3 types of casting machines. The choice is a matter of access and personal preference.

Casting Crucibles

1. Clay – high noble and noble crown and bridge alloys.
2. Carbon – high noble crown and bridge alloys, higher fusing gold based metal ceramic alloys.

3. Quartz (including ziccon alumina) – high fusing alloys of any type especially for those having high melting range and sensitive to carbon contamination (High Pd, Pd-Ag, Ni and Co based alloys).

Clearing the Casting

After casting has been completed, the ring is removed and quarched is water as soon as button exhibits a dull red glow.

Advantages of Quenching

- Noble metal alloy is left is as amended condition for burnishing, polishing and similar procedures
- When water contacts hot investment, violent reaction occurs and investment becomes soft and granular and casting is more easily cleared.

Surface of casting appears dark with oxides and tarnish is removed by "Pickling" i.e. heating discolored casting is an acid (50% HCl).

Sulfuric acid can also be used. Now ultrasonic devices are also available. Gold based and palladium based metal ceramic alloys and base metal alloys are bench cooled to room temperature before the casting is removed from the investment. Castings from these alloys are generally not pickled.

Compensation for Casting Shrinkage

In general, three distinct contractions for which compensation is required may take place during the casting process.

i. Shrinkage of pattern as a result of charge is temperature at which wax is prepared and subsequently invested.
ii. Contraction as a result of change is state from liquid to solid.
iii. Shrinkage from solidus temperatures to room temperature.

The compensation can be achieved is following ways

- Wax expansion (impractical)
- Setting expansion
- Hygroscopic expansion
- Thermal expansion
- Placement of two liners instead of one allows a greater setting and thermal expansion than does a single liner.
- Also setting, hygroscopic and thermal expansions can be controlled to certain extent by varying liquid: Powde (LP) ratio of the investment. The lower the L:P ratio, greater the potential for investment expansion.
- It can also be regulated by reducing the time of immersion of the setting process.
- The longer the delay before the investment is immersed is water bath, the less the hygroscopic expansion that occurs.
- Increasing burnout temperature and the water bath temperature increases expansion.

Clinical considerations casting defects, causes and their prevention

I. Dimensional errors is casting

	Problem	*Cause*	*Precaution*
1.	Casting too large	Excessive expansion	Use correct temperature
2.	Casting too small	Too little mould expansion	Heat the mould sufficiently
3.	Distorted casting	Distorted wax pattern	Correct handling of wax

II. Rough surface and fins on casting

Problem	Cause	Precaution
1. Rough surface	a. Investment breakdown b. Air bubbles on wax (nodules on casting) c. Weak surface of investment	Avoid over heating of mould and alloy – Correct use of wetting agent – Correct vacuum investing – Avoid too high W/P ratio-avoid dilution of investment for application of too much wetting agent
2. Fins or casting	Cracking of investment	Avoid too rapid heating of investment

III. Rough surface and gas on casting

Problem	Cause	Precaution
1. Irregular voids	Shrinkage on cooling of alloy	– Use space of correct thickness – Attach space at thickness part – Reservior near attachment to sprue
	Inclusion of foreign	Heat mould upside down so that particles fall outside mould
Spherical voids	Occluded gases is molten alloy	Avoid over heating and prolonged heating of alloy
Rounded margins, regular large voids	Back pressure effect, air unable to escape from mould	– Use adequate casting force – Use porous investment – Avoid presence of wax residue is mould – Place pattern 6-8 mm away from end of firing
Porosity	Turbulent flow of molten alloy into the mould	Correct placement of sprue
Contamination	– Oxidation when molten alloy is over heated – Use of oxidizing zone of flare – Failure to use flux – Due to formation of sulphur compounds caused by breakdown of investment	– Avoid overheating – Use reducing zone – Use flux

25 Porcelain Material

INTRODUCTION

- Porcelain is defined as white translucent ceramic that is fixed to a glazed state.
- The term ceramic is derived from a Greek word "KERAMDS" means pottery or burnt earthware.
- Ceramics are compound of metallic and nonmetallic elements made of mixture of various naturally occurring minerals such as silicates, aluminates, oxides, carbides and other with varied and complex structures.
- They have some unique properties, most outstanding of these are high temperature strength and stability.
- Composition

Feldspar	- 60-80% - Basic glass former
Kadin	- 3-5% - Binder
Quartz	- 15-25% - Filler
Alumina	- 8-20% - Glass former
Oxides of Na, K and Ca	- 9-15% - Flux (Glass modifier)
Mettalic	- 1% - Color matching pigments.

Feldspar

- It is a naturally occurring mineral composed of potash (K_2O), Alumina (Al_2O_3) and silica (SiO_2).
- In its mineral phase feldspar is crystalline and opaque with an indefinite color between grey and pink.
- It acts as a flux, matrix and a surface glaze.
- When mixed with metal oxides and fired at high temperature it can form a glass phase that is able to soften and flow slightly. It fuses at temperature about 1290°C.
- Because of this, the porcelain powder particles coalesci, a process called Sintering (fusion of particles together without complete melting).
- On heating at fusion temperature it becomes glossy and retain its form without rounding, unless overheated.
- Iron and mica are commonly found as impurities in feldspar.
- Feldspar has a tendency to form the crystalline mineral leucite when it is melted. Leucite is a potassium aluminium silicate mineral with a large coefficient of thermal expansion ($20\text{-}25 \times 10^6/°C$) compared with feldspar glasses (10×10^6 /°C).
- This tendency of feldspar to form leucite during incongruent melting is exploited in the manufacturer of dental porcelains for fusing to metal.

Kaolin

- It is a white clay like material. It is a hydrated aluminium silicate.
- Kaolin gives porcelain its property of opaqueness.
- When mixed with water it becomes sticky and aids in forming the workable mass of porcelain during molding.
- When subjected to high heat, it adheres to the framework of quartz particles and shrinks considerably.

Silica

- It is obtained by grinding pure quartz.
- Silica remains unchanged at the temperature normally used in firing porcelain. This contributes stability to the mass during heating by providing a framework for the other ingredient.

Aluminium Oxide

- Replaces some silica in glass matrix.
- It gives strength and opacity to the porcelain.
- It alters softening point and increases the viscosity of porcelain during firing.

Fluxes and Glass Modifiers

- These are the metal ions such as sodium, potassium, calcium and carbonates.
- These ions associate with the oxygen atom at the corners of the silica tetrahedral and interrupt the oxygen silica bonds.
- As a result of 3-dimensional silica network contains many linear chains of silica tetrahedral which moves more easily at lower temperature and is responsible for increased fluidity (decreased viscosity).
- If concentration of flux is too high.
  - It reduces chemical durability of glass.
  - It may cause the glass to crystallize and devitrify.
- Another important glass modifier is water and accounts for the phenomena of slow crack growth.

Coloring Frits

- These are produced by fusing various metallic oxides with fine glass and feldspar and then grinding to powder.
- They are added to dental porcelains to obtain various shades to match natural tooth color.
- The metallic pigments include
  - Titanium oxide - Yellow brown shades
  - Iron oxide - Brown
  - Cobalt oxide - Blue
  - Copper or chromium oxide - Green
  - Nickel oxide - Brown
  - Uranium oxide - Fluorescence

PROPERTIES OF FUSED PORCELAIN

Strength

Porcelain is a material having good strength. However, it is brittle and tends to fracture. The strength of dental porcelain is measured in terms of flexural strength or modulus of rupture.

a. Flexural Strength
   - It is a combination of compressive, tensile as well as shear strength.
   - Glazed porcelain is stronger than ground porcelain
     Ground porcelain – 75.8 Mpa
     Glazed porcelain – 141.1 Mpa

b. Compressive Strength
   - Porcelain has good compressive strength.
   - It is 331 Mpa

c. Tensile Strength

- Tensile strength is low because of the unavoidable surface defects like porosities and microscopic cracks.
- When porcelain is placed under tension, stress concentrates around these imperfection can result in brittle fractures.
- It is 34 Mpa.

d. Shear Strength
- It is low and is due to the lack of ductility caused by the complex structure of dental porcelain.
- If is 110 Mpa.

Modulus of Elasticity

- Porcelain has a high modulus of elasticity.
- It is 69 GPa.

Surface Hardness

Porcelain is much harder than natural teeth 460 KHN.

Wear Resistance

Porcelain is more resistant to wear than natural teeth. Thus it should not be placed opposite to natural teeth.

Thermal Properties

a. Thermal conductivity – Porcelain has low thermal conductivity.
b. Coefficient of thermal expansion – it is close to that of natural teeth.

$$6.4 - 7.8 \times 10^{-6}/°C$$

Specific Gravity

The true specific gravity of porcelain is 2.242. The specific gravity of fired porcelain is usually less because of presence of air voids. It varies from 2.2-2.3.

Dimensional Stability

Porcelain is dimensionally stable after firing.

Chemical Stability

It is insoluble and impermeable to oral fluids also resistant to most solvent. However, contact with hydrofluoric acid causes etching of the porcelain surface.

Esthetic Properties

The esthetic qualities are excellent. It is able to match adjacent tooth structure in translucence, color and intensity. In addition attempts have also been made to match the fluorescent property of natural teeth, when placed under the UV light.

Biocompatibility

It is compatible with the oral tissue.

CLASSIFICATION

I. According to their Firing Temperature
- High fusing - 1290-1370ºC
- Medium fusing - 1095-1260ºC
- Low fusing - 870-1065ºC

II. According to Type
- Feldspathic or conventional porcelain
- Aluminous porcelain
- Glass infiltrated alumina
- Glass infiltrated spinel
- Glass ceramics

III. According to Use
- Porcelain for artificial teeth
- Jacket crown, inlay and veneer porcelain
- Metal ceramics
- Anterior bridge porcelain

IV. According to Processing Method
- Sintered porcelain
- Cast porcelain
- Marhined porcelain

V. According to the Method of Firing
- Air fired i.e. at atm pressure.
- Vacuum fired i.e. at reduced pressure.

Supplied as

A kit containing
- Fine ceramic powders in different shades of enamel, dentin, core/opaquer.
- Special liquid/distilled water.
- Stains or color modifier
- Glaze powder

Commercial Name

- Ivoclar
- Vita
- Dentisply

Manufacture of Porcelain Powder

- It is manufactured by a process called fritting.
- The various components are mixed, fused and then quenched in water.
- This results in internal stresses producing cracks and fracturing throughout glass and process is known as Fritting and product Frit.
- It is brittle and is ground to a fine glass powder during pre heating.
- The pyrochemical reaction occurs during manufacturing and much of the shrinkage associated with porcelain has taken place.
- During subsequent firing in dental laboratory powder is fused together to form restoration.

Technique for Use of Porcelain

- Tooth is prepared.
- An impression of it is taken and a working model or a die is formed of a suitable die material.
- The portion of the die to be contacted with porcelain is carefully covered with a thin layer of platinum foil 0.025 mm in thickness.
- Overlapping portion at the margins are either trimmed or soldered to provide a uniform thickness around are of the borders.
- This platinum form or matrix retains, the porcelain mix in the shape of the tooth preparation during firing and determines to a great extent, the accuracy of fit of the restoration.
- The porcelain powder in the color selected for the body or dentin portion is mixed with distilled water to a creamy consistency and is applied in the correct proportions to the platinum, matrix with allowances made for shrinkage.
- To produce minimum shrinkage and dense strong porcelain condensation is done.

METHODS OF CONDENSATION

1. **Vibration Method**
   Mild vibration is used to densly pack. The wet powder upon the underlying matrix. The excess water comes to the surface and is blotted with a tissue.
   Vibration may be
   (a) Manual – By rubbing a serrated instrument.
   (b) Ultrasonic
2. **Spatulation Method**
   A small spatula is used to apply and smoothen the wet porcelain. The action brings excess water to the surface.
3. **Brush Method**
   Dry powder is placed by a brush. Water draws towards the dry powder and the wet particles are pulled together.

Firing

- After condensation of material, the porcelain restoration is placed on a fire clay slab or tray and inserted in the muffle of a porcelain furnance.

- The purpose of firing is to fuse the particles of powder together properly to form the restoration.
- The condensation mass is placed in the front of the muffle of a preheated furnance (650ºC/1200ºF).
- The preheating procedure permits the remaining water to dissipate.
- Placement of a condensed mass directly into even a moderately warm furnance will result in a rapid production of steam thereby introducing voids.

Stages of Firing

There are 3 stages of firing known as bisque/ biscuit stage. The temperature at which each stage occurs depend on the type of porcelain.

1. **Low Bisque Stage**
   - In this stage the flux begins to melt & flows in between the porcelain particles.
   - The mass attains some rigidity.
   - But very little cohesion.
   - At this stage material is porus and undergoes minimum of shrinkage.
2. Medium Bisque Stage
   - At this stage flux flows freely in between the particles.
   - The material is still porus.
   - But there is complete cohesion between the particles.
   - Most of the shrinkage is complete.
3. High Bisque Stage
   - The shrinkage is complete.
   - There is very little porosity.
   - The mass has attained complete rigidity and smoothness.
   - The body does not appear to be glazed.

Note:
At any stage work can be removed, cooled and additions can be made. Less the number of firings, higher is the strength and better the esthetics. Too many firings give a lifeless, overtranslucent porcelain.

Glazing

After firing porcelain are glazed to a glossy surface.

Purpose

1. It enhances strength, esthetics and hygiene.
2. Glazed porcelain is much stronger than unglazed.
   - Overglazing gives the restoration an unnatural glossy appearance and may cause slumping loss of contour.
   - The fusing temperature of glaze are reduced by the addition of glass modifier and these glass modifiers lower the chemical durability of glazes.
   - Stains are tinted glazes.
   - Applied characterizing stains will be permanent if used internally.
   - Glaze is effective in reducing crack propagation.
   - If glaze is reduced by grinding transverse strength may be only half with the glaze present.

Types

- Overglaze: The glaze powder is mixed with liquid, applied over the smoothened crown and fired at temperature lower than that of body porcelain.
- Self Glaze : Porcelain can be self glazed by heating under controlled condition i.e. it is heated to its fusion temperature and

maintained for 5 min. It causes only the surface layer to fuse and flow over the surface to form a layer called glaze.

Cooling

- It must be carried out slowly and uniformly.
- If shrinkage is not uniform it causes cracking and loss of strength.
- During cooling subsurface submicroscopic surface cracks occur.
- Because of the low thermal conductivity of porcelain, differential between the outside and inside can introduce stresses which embrittle the porcelain.

Firing Shrinkage

- During firing due to loss of water and densification firing shrinkage occur.
- It concludes both volumetric and linear shrinkage.

Linear Shrinkage

Low Fusing	High Fusing
14%	11.5%

Volumetric Shrinkage

Low Fusing	High Fusing
32-37%	28-34%

Shrinkage is different for different tech of condensation.

Vibration	-	38.1%
Spatulation	-	38.4%
Brush Method	-	40.5%
No Condensation	-	41.5%

Compensation of Firing Shrinkage

It can be done by 3 methods.

1. **Crosscut Method**
   - It is accomplished by preparing the matrix as before and cutting a cross through the centric of porcelain to the matrix.
   - When fused, the section of porcelain separated by the cross will shrink towards the margin rather than towards the center.
2. **Ditching Method**
   - Prepare a matrix. Ditch is cut into the porcelain around the inner margins of matrix.
   - On fusion porcelain shrinks towards the center. The ditch will be enlarged but margins will remain partially covered.
   - Now the ditch is covered with fresh porcelain and the case fired a second and a third time.

Layer Method

- Porcelain is built on in successive layers which are built higher in the center.
- Each layer being fused to a biscuit bake before another is added.
- By hilling up the layer each is shingled over the other at the margins and shrinkage is avoided.

POROSITY

- As the temperature is raised, the fused glass gradually flows to fill up the air spaces. However, air become trapped in the form of bubbles because the fused mass is too viscous to allow all the air to escape.
- It reduces translucency and strength.
- An aid in the reduction of porosity is

Vacuum Offset Firing

- When PJC and PFM is placed into the furnance, the powder particles are packed together with air channels around them.

- As air pressure inside the furnance muffle is reduced to 1/10 th of atmospheric pressure air around the particle is also decreased.
- As the temperature is raised and the particles sinter together, closed voids are formed.
- At temperature about 55ºC below the upper firing temperature, vacuum is released.
- Because the pressure is increased by a factor of 10, the voids are compared to 1/10 of their original size and the total volume of porosity is thereby reduced.

In order to overcome the principal deficiencies of brittleness and low tensile strength of porcelain different methods have been used.

A. Methods of strengthening brittle material.
B. Methods of designing components to minimize stress concentration and tensile stresses.

A. Strengthening Brittle Material

It is done by:

a. Introduction of residual compressive stresses into the surface of the material.
b. Interruption of crack propagation through the material.

Introduction of Residual Compressive Stresses

Strengthening is gained by virtue of the fact that these residual stresses must be negated by the applied force before any tensile stresses can be created in the object. Some of the techniques for introducing residual compressive stresses are –

1. Ion Exchange

- If a sodium containing glass article is placed in a bath of moiten potassium ions in the bath exchange with Na^+.
- The K^+ is about 35% larger than Na^+.
- Squeezing of K^+ into the place formerly occupied by the Na^+ account for stuffing.
- This creates very large residual compressive stresses. (700 MPa / 100,000 psi).
- It is also called chemical tempering.

2. Thermal Tempering

- This creates residual compressive stresses by rapidly cooling the surface of the object while it is hot and is in the softened state.
- The rapid cooling produces a skin of rigid glass surrounding a soft molten core.
- As molten core solidifiers, it tend to shrink but the outer skin remains rigid.
- The pull of the solidifing molten core as it tries to shrink creates residual tensile stresses in the core and residual compressive stresses in the outer skin.

3. Thermal Expansion Coefficient Mismatch

- Consider three layers of molten glass the outer two of the same composition and thermal expansion and inner layer of a different composition and a higher thermal expansion.
- The layers are bonded together and allowed to cool at room temperature.
- The inner layer has a high coefficient of thermal expansion and thus expands and contracts more and creates compressive stresses in the outer layer.

Interruption of Crack Propagation

Ceramic is reinforced with a different phase of a different material that is capable of hindering a crack from propagating through the material.

Two types of dispersion used are:

i. Relies upon the toughness of the particle to absorb energy from the crack.
ii. Relies upon a crystal structure change under stress.

1. Dispersion of a Crystalline Phase

- When a tough crystalline material such as alumina (Al_2O_3) is added to a glass in a particulate form, the glass is toughened and strengthened because the crack cannot penetrate the alumina particles as easily as it can glass.
- It requires a close match between the thermal expansion coefficients of the crystalline material and the surrounding glass matrix.

Transformation Toughening

- It involves the incorporation of a crystalline material that is capable of undergoing a change in crystal structure when placed under stress.
- The crystalline material usually used is partially stabilized zirconia (PSZ).

B. Design of Dental Restoration Involving Ceramics

- Dental restoration involving ceramics should be designed in such a way as to accommodate their weakness.
- The design should avoid having the ceramic subjected to high tensile stresses.
- It also should avoid stress concentration from sharp angles or sudden changes in thickness.

1. Minimizing Tensile Stresses

Conventional PJC are contraindicated for

a. Restoring posterior teeth
b. On anterior teeth when there is a great amount of vertical overlap.
   - So metal coping are used as foundation of the restoration to which the porcelain is fused.
   - The strong yet more ductile coping of portion of the crown from being subjected to large tensile stresses.
   - Both bonded platinum foil porcelain jacket crown technique and the swaged gold alloy foil technique are based upon this concept.

2. Avoiding Stress Concentration

- Folds of the platinum foil matrix that become embedded in the porcelain will leave notches that will act as stress raiser.
- Sharp line angles in the preparation also will create areas of stress concentration.
- Sudden changes in porcelain thickness determined by tooth preparation will create areas of stress concentration.

So the design of ceramic dental restoration should avoid stress concentration in the ceramic.

Factors Affecting Stress

1. Composition
2. Surface integrity – surface imperfections like microscopic cracks and porosities reduce the strength.
3. Firing procedure – inadequate firing weakness the structure as verification is not complete, over firing also reduces the strength as much of the core gets dissolved in the fluxes thereby weakening the core network.

ALL CERAMIC RESTORATIONS

Ceramic Jacket Crown

- The ceramics employed in the conventional PJC are high fusing feldspathic porcelain.
- The brittleness of porcelain requires that a layer of nearby equal thickness be placed over the entire tooth to avoid areas of weakness.
- All outside forces should be directed if possible at right angles to a plane of supporting tooth structure.
- Jacket is formed from several overlapping layer of porcelain, and each layer must be built oversize to allow for shrinkage.
- Its relatively low strength prompted McLean and Huges to develop an alumina reinforced porcelain core material for the fabrication of PJC.
- In this case porcelain contains 40-50% of alumina crystals.
- Body porcelain of usual glass type is fired over aluminous core and then enamel porcelain is applied.
- Alumina crystals are much stronger than quartz and are much more effective in interrupting gaps of propagation.
- The porcelain to be used with alumina crystals should have same coefficient of thermal expansion.

Composition of Aluminous Porcelain

Alumina	87.7%
Silica	7.1%
CaO	1.61%
MgO	1.32%
K_2O	0.36%
Cr_2O_3	1.13%
FeO	0.25%
TiO	0.13%
NaO	0.4%

Properties

Tensile strength	20000 psi
Compressive strength	3 lakh 16000 psi
Modulus of rupture	55000 psi
Coefficient of thermal expansion	6.6 x 10^{-6} ºC

Advantages

1. Adequate strength for most anterior crowns
2. Esthetic superior to porcelain fused to metal for a given shade and technician.
3. Elimination risk in choosing alloy.
4. Less expensive than metal ceramic crowns.
5. Requires less removal of tooth structure.

Denture Teeth

- The raw material for porcelain denture teeth are mainly feldspar along with about 15% quartz and 4% kaolin clay to improve mouldability.
- Plastic mass is made from this mixture containing pigments and is packed into metal molds and fixed under vacuum to reduce porosity.
- During firing the porcelain teeth are glazed by the glass produced by the feldspar.
- Metal pins or holes are placed in the teeth during manufacturer for mechanical attachment to the denture base.

Advantages

1. Excellent biocompatibility
2. Natural appearance
3. High resistance to wear and distortion

Disadvantages

1. Brittle
2. Does not bond to acrylic denture base and require mechanical attachments

3. Produce clicking sounds on contact
4. Can not be easily polished after grinding
5. Higher density increases weight of teeth
6. Mismatch in coefficient of thermal expansion produces stresses in acrylic denture base
7. When used against material teeth leads to its wear

Porcelain Fused to Metal (PFM)

The chief limitation of all porcelain restoration is its lack of strength, to minimize this disadvantage porcelain is fused directly to a metal coping that fits the prepared tooth.

Fusing porcelain directly to a metal is K/S metal ceramic or porcelain fused to metal. The development of the ceramic metal restoration was made possible as the result of:

1. Low fusing ceramics
2. High fusing alloys
3. Ceramics and alloys that have matching coefficient of thermal expansion.
4. Ceramic and alloys that form a strong bond.
5. Alloy with high proportional limit.

Composition of Ceramics

The basic composition is same except:

1. Alkali content (soda and potash) are increased in order to raise coefficient of thermal expansion to match that of metal to which it is fused. But higher alkali content gives a tendency to devitrify porcelain and appear doudy.
2. For marking the color of metal, opacifiers are added in the 1st layer.

Composition of Alloy

Two classes of alloys are used:

1. Nobel metal alloys
2. Base metal alloys

Enamel Metal Bonds

They are divided into 3 main components:

1. Mechanical
2. Compressive
3. Chemical

Mechanical Retention

- It is dependent upon good wetting of the metal or metal oxide surface by the porcelain.
- Mechanical retention is enhanced by a rough surface.
- The smaller the contact angle better is the cutting efficiency of the porcelain.

Compressive Stresses

- Compressive stresses set up during the cooling of the sintered porcelain veneer.
- So ceramo metallic systems are designed with a very small degree of thermal mismatch to leave the porcelain in a state of stress.

Chemical Bonding

- Indium or tin migrates to the alloy surface to form oxides which combine with the porcelain during firing.
- Cleansing of metal with hydrofluoric acid reduces the bond strength this indicates that oxide layer contributes to bonding.

Bonding Using Electrodeposition

Ceramic bonding to metals in certain cases requires the electrodeposition of metal coatings and heating to form suitable metal oxide. A layer of pure gold is deposited onto the cast metal, followed by a short flashing deposition of tin.

Advantages

1. Improve the wetting of porcelain onto the metal and reduce the amount of porosity at metal porcelain interface.

2. Electrodeposited layer acts as a barrier between the metal casting and the porcelain to inhibit diffusion of atoms from the metal into the porcelain within the normal limits of porcelain firing cycle.

Proprietary Agents

- They are intended for application to the metal surface before condensation of opaque porcelain layer.
- They are applied as thin liquid to the metal surface and are fired.
- Opaque porcelain is then condensed over it in usual manner.

Function

1. These agents improve metal ceramic bonding by limiting the build up of an oxide layer on the base metal surface during firing.
2. They can improve esthetics by helping to block the color of the dark metal oxide.

Types of Metal Ceramic System

A. Cast Metal Ceramic Alloys

1. **Nobel metal alloys systems:**
   High gold a. Gold, platinum, palladium
   Low gold b. Gold, palladium, silver
   Gold Free c. Palladium, silver
2. **Base metal alloy system**
   Nickel, chromium, alloy
   Cobalt, chromium, alloy

B. Foil Copings

The thicker cast metal coping that is normally used is replaced by a thinner platinum foil thus allowing more space for the porcelain.

1. **Bonded Platinum Foil Coping**
   Platinum foil is electroplated with a thin layer of tin. It is then oxidized in furnance. Aluminous porcelain is then added to the tin oxide.
2. **Swaged Gold Alloy Foil Coping**
   - Renaissance and alloy foil coping are products designed to fabricate the metal copying of a metal ceramic crown without the use of melting and casting process.
   - A swaged gold alloy foil supplied in fluted shaped is swaged onto the die and flame sintered to form a coping.
   - An interfacial alloy powder is applied and fired and the coping is then veneered with porcelain.

Classification of Bond Failure in Metal Ceramics

Given by O. Brien (1977):

1. **Metal porcelain**
   Fracture leaves a clean surface of metal:
   (a) Seen when metal surface is devoid of oxides.
   (b) Due to contaminated or porus metal surface.
2. **Metal oxide porcelain**
   - Porcelain fracture at metaloxide surface leaving oxide firmly attached to metal.
   - Seen more often in base metal alloy system.
3. **Metal – Metal oxide**
   - Metal oxide breaks away from the metal and in left attached to porcelain.
   - Seen more commonly in base metal systems due to excess chromium and nickel oxide.
4. **Metal oxide – Metal oxide**
   - Fracture occurs through the metal oxide.
   - Results from over production of oxides.
5. **Cohesive within metal**
   - More common in bridges where the joint area breaks.
   - Rarely seen in single crown.

6. **Cohesive within Porcelain**
   - Tensile failure within porcelain bond strength exceeds strength of porcelain.
   - Seen in high gold content alloy.

TECHNICAL CONSIDERATION FOR METAL CERAMIC RESTORATION

Metal Preparation

- A clean metal surface is essential.
- The surface is finished with ceramic bonded stones or sintered diamonds.
- Final texturing is done by sand blasting with an alumina air abrasive.
- Then cleaned ultrasonically, washed and dried.

Degassing

- Gold porcelain system is heated at 980ºC to burn off impurities and degas it.
- Degassing also serves to form an oxide layer on the alloy surface which helps in bonding.

Opaquer

- Opaque porcelain is condensed with a thickness of approximately 0.3 mm and is then fired to its maturing temperature.
- Translucent porcelain is then applied and tooth form is built.

Cooling

- Cooling of PFM restoration is a complex matter.
- Cooling too slowly can cause the coefficient of thermal expansion of porcelain to increase and make it more likely to crack or craze.

Recent Advances in Porcelain

Many new all ceramic materials and systems have been introduced for crown and bridge application. These include

1. **Magnesia Core Porcelain**
- It is used as an alternative to the aluminous core material.
- Magnesia core has a high coefficient of thermal expansion 14.5 x 10^{-6}/ºC.
- The strength is 138 MN/$m.^2$
- The main advantage of this core material is that it allows more widely available porcelain for bonding to metals for reinforced jacket crown construction.

2. **Castable Glass Ceramics**
   - Glass ceramic is a material fabricated in the vitreous or noncrystalline state and then converted to a crystalline state by heat treatment or ceramming process.
   - It is used for forming crowns by lost wax process.
   - Composition – It is comprised of SiO_2, K_2O, MgO, MgF_2, AlO_3, ZnO_2 and a fluorescing agent.
   - Widely used glass ceramic product in India is silica that crystallizes to form mica upon heat treatment.
   - A phosphate bonded investment mold is used in lost wax process.
   - The mild temperature for casting is 900ºC.
   - The casting temperature of glass is 1380ºC.

Advantages

1. It has excellent marginal fit.
2. It is biocompatible less plaque accumulation around dicor crown is because:
   a. Marginal adaptation is exceptional.
   b. The fluoride content of the material inhibits bacterial colonization.

c. The surface of the restoration is smooth and nonpours.

3. It has high strength.
4. It is compatible with the lost wax casting process.
5. The surface hardness and occlusal wear of dicor in similar to enamel.
6. The material has low thermal conductivity so insulate the tooth from change in temperature.
7. The most significant advantage of this restoration is its life like vitality.

Disadvantage

- Low fusing feldspathic porcelain shading must be applied for good color matching.

3. CAD-CAM Ceramic (Ceres System)

- It is an acronym for computer aided design/computer aided manufacturing.
- It can fabricate ceramic inlays and onlays out of very high quality ceravics in a matter of minute.
- It first scans the prepared cavity image and a computer aided copy milling machine reproduces it onto a block of ceramic by grinding with diamond disc.

Advantages

1. Only one appointment needed
2. Reduced chairside time
3. Impression not required
4. Negligible porosity

Disadvantages

1. Costly equipment
2. Image scanning is technique sensitive

4. Cerestore
   - The innovative feature of cerestore system is the dimensional stability of the core material in the molded (unfixed) and fixed state.
   - The cerestore material off sets conventional ceramic shrinkage by a combination of chemical and crystalline transformation.

Chemical Transformation

Silicone resin used as the binder, diving transfer molding changes from SiO to SiO_2.

Crystalline Transformation

Compensation involves combining the constituents so that the transformation during firing results in the fired ceramic components occupying a great volume than a raw ingredients.

Advantages

1. Increased flexural strength.
2. Low coefficient of thermal expansion.
3. High modulus of elasticity.
4. Radiodensity similar to that of natural enamel.
5. Marginal integrity generated by direct molding without distoration during veneer application.

Disadvantages

1. Specialized laboratory equipment needed.
2. Tooth preparation requires close attention to detail.
3. Not recommended in patients with heavy bruxism.
4. Contraindicated in long span FPD.

4. Injection Moulded Glass Ceramics

- It is preceramed glass ceramics that is heated in a cylinder form and injected under pressure and high temperature into a mould.
- It contains high concentration of leucite crystals that increase the resistance to crack preparation.

- The material is injected moulded over a 45 min period at high temperature to produce ceramic substructure.

Advantages

1. Lack of metal or opaque ceramic core.
2. Excellent fit
3. Radiolucency and biocompatibility

Disadvantages

1. Complexity and cost of process.

5. Glass Infiltrated Alumina Core Ceramic

- The slightly sintered aluminous porcelain core is infiltrated with glass at 1100°C for 4 hours to eliminate porosity and increase strength.
- The initial sintering process for alumina produces minimum volume decrease because temperature and time are sufficient only to cause bonding between particles at small areas.
- Indicated for single anterior and posterior crowns and anterior 3 unit bridges.

Advantage

- Excellent marginal fit.

Disadvantages

- Opacity of core.

6. Leucite Reinforced Porcelain (Optech HSP)

Leucitie is a crystal phase (K_2O, Al_2O_3, $4SiO_2$) optech HSP is a leucite reinforced feldspathic porcelain that is condensed and sintered like aluminous porcelain and traditional feldspathic porcelain.

Advantages

1. It has moderately opaque core as compared to metal or aluminous porcelain core so more translucent than aluminous core crown.
2. Its strength is higher than feldspathic porcelain.
3. It does not require the metal substructure.

Disadvantages

1. It has potential marginal inaccuracy caused by porcelain sintering shrinkage.
2. It can fracture in posterior teeth.
3. It is recommended for inlays, onlays, low stress, crowns and veneers.

7. Renaissance (Bonded Gold Platinum Material Restoration)

- They consist of a thin metallic matrix bonded to overlying porcelain. They are not true all ceramic restoration.
- Fabrication involves the use of matrix which is 51-58 mm thick. The matrix is composed of multiple thin layers of metal bonded together.
- There is a central layer of pure palladium that is covered internally and externally by gold palladium alloy.
- The matrix is then adapted to die and heated in a flame until gold flows and creates a soldered union between matrix folds.
- The bonding agent is applied and fired after which thin layer of opaque porcelain is placed and fired.
- Dentin and enamel porcelain are then built fired and glazed.

CONCLUSION

Dental ceramic technology is one of the fastest growing areas of dental material research and development. This material is gaining interest because it is one of important tooth colored restorative material and now a days people are becoming more esthetic conscious. Recent advancements in ceramic products with improved fracture resistance and esthetic capability have led to a slight increase in the use of all ceramic products.

26 Dentine Hypersensitivity

DEFINITION

Defined as pain arising from exposed dentin typically in response to thermal, chemical or osmotic stimuli it cannot be explained as arising from any other form of dental defect or pathology.
Or

Exaggerated response to non-noxious sensory stimuli. It is basically a chronic situation with acute episodes.

It should be differentiated from dental pain which is a response to noxious stimulus and is a acute condition.

PREVALENCE

One out of seven people (1:7)
Males more than female
Age – 20 to 40 years (30 years)
Less as age increases due to
1. Laying down of sclerotic or secondary dentine which blocks the tubules.
2. More fibrosis of pulp

ETIOLOGY

Due to exposure of dentine and presence of open dentinal tubules on the surface.

Two types:
1. Sudden pain at an isolated site.
2. Generalized hypersensitivity and degree of pain varies from time to time due to dynamic equilibrium between the factors which tend to occlude the tubules and open up the tubules.

Measures of Sensitivity

Vabal rating scale – stimulate the area with compressed air.
0 – no discomfort
1 – mild
2 – moderate
3 – severe
Electronic pressure sensitive probe keep it and rub it over plastic impression syringes – keep it on area for three seconds and check for response.

Causes

1. Loss of enamel – para function habits
   – occlusal wear
   – toothbrushing abrasion
   – dietary erosion
2. Denudation of root surface – gingival recession, aging, chronic periodontal disease, abnormality position tooth in arch, exposure after periodontal surgery, incorrect toothbrush.

Theories of Hypersensitivity

Direct Nerve Stimulation Theory or Neural Theory (Fig. 26.1)

Suggest that the response of patient is due to excitation of the nerve endings present within the tubules and nerves signals are

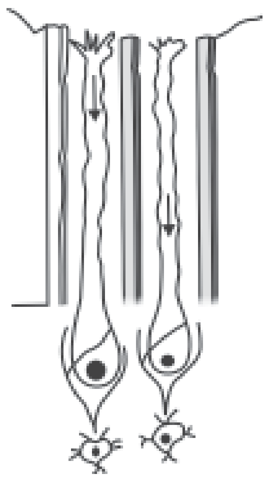


Fig. 26.1: Neural theory

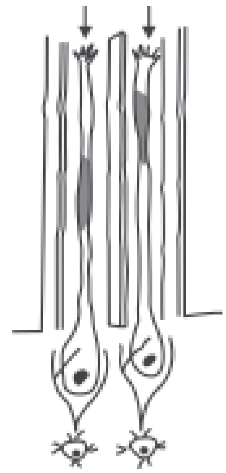


Fig. 26.2: Odontoblast transudation theory

then conducted along the afferent nerve into the pulp into the pulp and from there to the brain.

- Not accepted an nerve fibres are less near the exposed surface. Nerves are in plenty only in deep inner dentin.
- These intratubular nerves arise only after sometimes after eruption and does not extend to occlusal surface and sensitivity may be present at the time of eruption.

Odontoblast Transudation Theory (Fig. 26.2)

Stimuli initially excite either the processes or body of odontoblast. Odontoblast is close to nerve so stimulates the nerve which in turn stimulates the brain.

Not accepted–there is no evidence of synaptic relation present between odontoblast and nerve.

Hydrodynamic Theory (Fig. 26.3)

Accounts for the pain transmission by small rapid movements of fluid that occur within the tubule. according to this fluid movement in the dentinal tubule brings of the pain transmission. mechano receptors nerves are seen around the odotoblastic process when the fluid is stimulated – nerves are stimulated – pain.

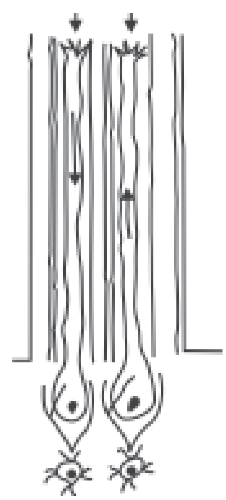


Fig. 26.3: Hydrodynamic theory

Movement of fluid may be due to cutting pressure changes, osmotic changes etc.

If tubules are full there is less space for fluid to move. If the tubule is empty there is more space for fluid to move, so mere is the pain.

Treatment of Hypersensitivity

1. Tubular occlusion
2. Iontophoresis
3. Inhibit sensory nerve activity

Grossman's Criteria for Desensitizing Material

1. Non-irritant
2. Should not endanger integrity of pulp
3. It should be painless on application
4. It should be easily applied either by dentist
5. It is rapid action
6. It is permanently effective
7. It should not discolor tooth structure

Treatment Modalities

- Chemical agents.
- Physical agents.

Clean the Tooth

- Rubber cups
- If root – root planning instruments.
- Remove hards soft deposits.
- Isolate and dry the area.
- Protect the soft tissues for the agent.
- Caustic effect.

Chomical Agents

1. Corticosteroids
   - When hypersensitivity was thought to be due to pulpal irritation.
   - Used topically
   - Found ineffective now a day.
2. $AgNo_3$ and $ZnCl_3$:

Acts by its ability to ppt. Protein of odontoblastic process. Thereby locking the fibrils.

Disadvantage: Lead to staining of teeth and harmful to gingival and pulp.

Mechanism of Action

1. $Ca(OH)_2$: It blocks the dentinal tubules. Promote peritubular dentine formation. Exposed dentine.
   Ca combine with full protein and brings abt. Reminecalcification of exposed dentine.
   Blocks the tubules.
4. Fluoride Compound:
   They also form a calcific barrier – 2% Aquous solution or 33% paste with or without iontophoresis.
   a. Na fluorophosphate: (Present in tooth paste)
   b. Stannous fluoride: Sr ion combine with tooth structure (dentine) and occlude the tubules.
5. KNO_3 and potassium oxalate: K bring about inhibitory effect on nerve activity.
   K-ions
   ↓
   Enter the sensory nerve
   ↓
   Prevents depolarization
   ↓
   Inhibition of nerve activation
6. Fluoride iontophoresis: Iontophoresis device is attached to tooth and tooth substance is positive charges and negative ions are forced into the tubules.

Physical Agents

1. Burnishing of dentin: With Nal, glycrecrine using orange wood sticks.
   Rub on tooth surface – Produces smear layer.
   Occluding the tubule.
2. Varnish and scalants: Temporary.
   F- containing (Duraphat).
   Varnish
3. Composite adhesive and dentine bonding agent:

They attach to tooth by lining of

a. Micor/Macro tage called micro-mechanical bonding.
b. By forming hybrid layer.

After etching apply a primer – it primer – it crosses the smear layer and combines with collagen of dentine forming hybrid layer.

4. IV and V Generation bonding agent
   IV Scotch bond
   V Primer bond (Primer and bonding agent)
5. Soft fissure grafts: Denudation of rock surface are covered with.
6. Liners.

27 Non-carious Hard Tissue Lesions

INTRODUCTION

Lesion is any pathological or traumatic disorder of tissue or loss of function of part. With regard to teeth, carious lesions are the most common constitute 75% of the tooth destruction. The remaining 25% of the tooth destruction originate from regressive alternations of teeth, in hereditary and hereditary defects of enamel and dentin, resorption, inflammation. Some of the changes can be associated with general aging process. Some of the lesions may not be related etiologically or pathogenically. Together these lesions from the group of non-carious lesions.

They can be broadly classified as:

A. Wasting diseases of teeth:
   1. Attrition
   2. Abrasion
   3. Erosion
B. Non-carious lesions of enamel
   1. Localized non-hereditary enamel hypoplasia
   2. Localized non-hereditary enamel hypocalcification
   3. Amelogenesis imperfecta.
C. Non-carious lesion of dentin
   1. Localized non-hereditary dentin hypoplasia
   2. Localized non-hereditary dentin hypocalcification
   3. Dentinogenesis imperfecta
   4. Dentin sclerosis
   5. Irritation dentin
   6. Dead tracts
D. Non-carious lesion of cementum
   1. Cementum hypoplasia
   2. Cementicle
E. Pulp calcification
F. Resorption

WASTING DISORDERS OF TEETH

Wasting is defined as gradual loss of tooth substances characterized by formation of smooth polished surfaces, without regard to possible mechanism if loss.

Attrition (Fig. 27.1)

According to Shafer, attrition may be defined as the physiologic wearing away of a tooth as a result of tooth-to-tooth contact as on mastication.

According to Marzouk, attrition may be defined as surface tooth structure loss resulting from direct frictional forces between contacting teeth.

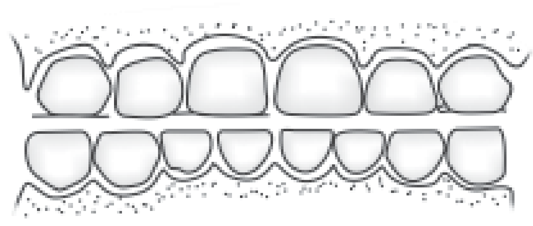


Fig. 27.1: Attrition

Attrition is a continuous, age-dependent process, which is usually physiologic. Any contacting tooth surface is subjected to attrition process. Beginning from the time it erupts into the oral cavity and makes contact with reciprocating tooth. It occurs on the occlusal, incisal, and proximal surfaces of teeth. It may be seen in the deciduous or permanent dentition, but severe attrition is rarely seen in deciduous teeth, as they are not retained for a very ling time. Men usually exhibit more attrition than women of comparable age probably as a result of greater masticatory forces of men.

Etiology

- Patients with accelerated parafunctional mandibular movements- e.g. bruxims.
- Diet—persons with habit of chewing tobacco or having a coarse diet are more predisposed to attrition.
- Certain occupations, in which worker is exposed to abrasive dust and cannot avoid getting the material in to his mouth, can have attrition.

Clinical Features

Attrition can predispose to or precipitate to any of the following.

Proximal Surface Attrition

This results from surface tooth structure loss and flattening—widening of proximal contact areas. Because of this process, the proximal surface which is susceptible to decay will increase in dimension. At the same time, cleansability will be affected due to decrease in dimension of surrounding embrasures.

- M-D dimensions of the teeth will be decreased, leading to drifting, resulting in alteration of physiologic occlusion.
- Interproximal space will be decreased in dimensions thereby interfering with plaque control, which can lead to periodontitis.

Occlusal Surface Attrition

This is the loss, flattening, faceting and/or reverse cusping of occluding elements. 'Reverse cusp' situation arises in severe cases usually in the cusp tips and inclined planes. This will cause loss of vertical dimension which can affect the facial appearances in two ways:

- If occlusal wear is severe, generalized and accomplished in a relatively short time, there would be no chance of alveolar bone to more occlusally to compensate for tooth loss. In this case, loss of vertical dimension can be imparted on the face. This will also result in over closure during mandibular functional movement, which in the longrun will strain the stomatognathic system.
- If the loss occurs over along period of time (10 years or more), the alveolar bone can grow occlusally bringing the teeth to their original termination. In other words, vertical dimension loss will be confined to teeth but not imparted to the face.

Masticating abilities can also be affected from occlusal wear. Blunting (flattening) of cusps will compel patient to apply more force while chewing. These extra forces can strain masticatory muscles, the teeth, periodontium and TMJ.

Cheek biting is another sequela of attrition with the flattening of occlusal surface, the vertical overlap between the inclined planes will be lost. This will cause surrounding lips, cheeks, tongue to be fed between the teeth with their possibility of being crushed during dynamic contact.

Gingival irritation can also occur due to proximity of occlusal table to gingiva.

Decay can be another sequela for attrition as the underlying dentin will be exposed and thereby become more susceptible to decay. This, however, happens if attrition is a rapid process. But if it is slow then irritation to the odontoblasts process results in formation of secondary dentin. However in reverse cusp situation, susceptibility to decay will be increased.

Tooth sensitivity which is a common symptom of attrition may be due to many factors like dentin exposure, pulp strangulation due to excessive non-physiologic process, microcracks, stagnation of irritating substances on created flat or concave areas of dentin.

In case attrition present only on one side, then the opposite side occluding elements will act as interfering points creating stress on TMJ and surrounding musculature.

Treatment

Attrition can involve one inclined plane to involvement of all occluding surfaces. Sometimes process of attrition may be slow and at other times it may be rapid associated with pulp exposure. Therefore, it should be chosen according to type and stage of attrition. These include:

a. If attrition is due to certain parafunctional habits, e.g. brusixm, it should be corrected by construction of occlusal splints, coronoplasty, drugs like anti-depressants.
b. In case of direct pulp exposure, root canal therapy should be initiated if sufficient crown length is available or else extraction may be alternative choice.
c. Occlusal equilibrium should be done if attrition is present only on one side. Occlusal equilibration, by selective grinding of tooth surfaces include rounding or smoothening the peripheries of occlusal table. Also one should create adequate overlap of working inclines.
d. Use of fluoride application should protect dentin sensitivity due to attrition. If attrition has caused facets formation then these cavities should be filled with a restorative material.
e. *Restorative modalities:* Since attrition usually occurs in high stress bearing areas, only metallic restorations should be used to replace them.

Restorations are indicated in following cases:

a. Noticeable loss of vertical dimensions that has not been compensated for and should be regained to effect a physiologic status in stomatognathic system.
b. There is extressive loss pf tooth structure necessitating restoring tooth to enamel function.
c. Carious lesion superimposed on attrition.
d. A tooth is cracked or endodontically fractured.

One important step in restoring attrited teeth is regaining lost vertical dimension. This can be done by measuring the vertical dimension lost. This is done by first measuring the vertical dimension of patient when at rest and in centric occlusion. A difference between these will give estimate of free way space which should be between 2-3 mm. The difference between measured vertical dimension and freeway space will give estimate as to how much we should increased height of worn clinical crowns.

If increase in vertical height is to be more than 2 mm, then this increase should not be sudden as it can affect the TMJ which was probably undergone a permanent physiologic accommodation. In such cases, gradual increase in vertical dimension is done by temporary restorations. The increase in vertical dimension is done periodically till the point of intolerance is felt. Then it is reduced till no intolerance is present and it is at this height that crowns are constructed.

Permanent restorations should always be done in cast alloys.

- In case of short clinical crown, intradicular retention may be required by devitalizing the crown or using other extracoronal retention forms.

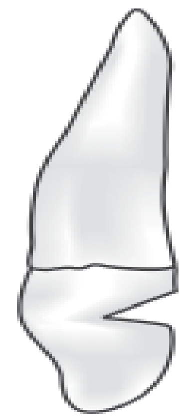


Fig. 27.2: Abrasion

Abrasion (Fig. 27.2)

According to Shafer, abrasion is the pathologic wearing away of tooth substances through some abnormal mechanical process.

According to Marzouk, abrasion can be defined as surface loss of tooth structure resulting from direct friction forces between the teeth and external objects.

Attrition usually occurs on exposed root surfaces, through it can be seen elsewhere such as cervical or proximal surfaces. If the process is slow, it leads to formation of secondary dentin intrapulpally, causing recession of pulp and root canal tissues away from advancing lesions pulpal limit. But if the process is aggressive then it leads to a direct pulp exposure.

Etiology

The most common causes of abrasion is the faulty use of tooth brush carrying a dental abrasive. Tooth brush can cause wear of cementum and dentin if it is injudiciously used, particularly in horizontal rather than vertical direction.

Abrasion can be caused due to certain habits. The habitual opening of pins with teeth may result in notching of the incisal edge of maxillary central incisor. Chewing tobacco can cause generalized occluding surface abrasion.

Certain occupation, For example, carpenters, tailors, shoemakers who hold nails, tacks, pin which between their teeth can develop incisal notching.

Forcing tooth pins, interdental stimulator, or the solid plaque control devices interproximally can cause proximal surface abrasion.

Pica syndrome which is due to habit of chewing clay has a specific occlusal abrasion pattern.

Iatrogenic causes, such as porcelain restorations or cast metal restorations opposing a natural tooth can cause occluding surface abrasion. The abrasive process can be aggressive if restoration has occlusal interferences built it into it.

Tooth Brush Abrasion

The surface extent, depth and rate of formation is dictated by;

a. Direction of brushing strokes — Horizontal strokes are more detrimental.
b. Size of abrasive — larger the particle size greater is the process of abrasion.

c. Type of abrasive — Silica abrasives are more detrimental than phosphate or carbonate ones.
d. Type of brushes — natural bristles are more abrasive than synthetic ones. More the diameter of bristle more will be the abrasion.
e. Forces used for brushing — more the force used more will be abrasion. In fact, abrasion is more common on left side for right handed people and vice versa.

Clinical Signs and Symptoms

- Abrasive lesion is linear in outline, following the path of brush bristles, peripheries are angularly demarcated from adjacent tooth surface.
- It is V shaped or wedge shaped defect on the root side of CEJ in teeth with some gingival recession with the angle of the V being a rather sharp one.
- The exposed dentin will be smooth, polished and it rarely has any plaque accumulation or carious activity.
- Lesion may be extremely sensitive.

Treatment

- Diagnose the cause of abrasion. There is no use in treating or restoring teeth if cause of abrasion is still in action. Otherwise restoration will be abraded. If abrasion is due to certain habits then try and correct the habit and then go for restoration.
- If habit cannot be broken, restorative treatment can pass the effect of habit, i.e. if it is localized and non-interfering with stomatognathic system, pulp dentin organ or periodontium then these areas can be included in the restoration. Restoration should prevent any further destruction of the tooth. If habit is generalized and substantial, habit has to be discontinued or controlled.
- If abrasive lesion is a small one not exceeding 0.5 mm, it can be treated by smoothening the edges of the lesions so that it is in contour with surrounding tooth surface. This is done for esthetic or plaque control reasons. This is followed by application of fluoride solution.
- If involved teeth are extremely sensitive, it preferably to desensitize exposed dentin before restorative treatment. This can be accomplished by application of fluoride solution, i.e. 8-30% sodium or stannous fluoride for 4-8 minutes, or iantophoresis using a electrolyte containing fluoride ions/galvanic energy supplied to the tooth in the presence of electrolyte drives the fluoride ions deep into the dentin.
- If the abrasive lesions involve an anterior tooth or facially conspicuous area of posterior teeth at a non-occluding tooth surface, restoration can be done with any tooth colored restorative materials. In most cases no cavity preparations is needed if physiochemically adhering direct tooth colored materials is used.
- If lesions are in a non conspicuous area of a posterior tooth, a cast metal restoration can be indicated. But if pulp vitality could be affected then, a direct tooth colored restorative material with physiochemical bonding to tooth structure can be used; though with frequent replacement.

Erosion

According to Marzouk, erosion can be defined as the loss of tooth structure resulting from chemico-mechanical acts in the absence of specific microorganisms.

Sturdevant, who calls this, chemical erosion defines it as the loss of tooth structure by chemical actions in the continued presence of demineralizing agents like acids.

The teeth involved in erosion mainly depends on the etiological factor.

Etiology

Various causes have been given for etiology of erosion. These are:

a. *Ingested acid:* Especially citric acid, if consumed in large amount in form of lemon and citrus fruits can initiate and erosive lesion. Also, other acids found in beverages and mouth freshners can cause erosion. In such cases, labial surfaces and incisal edges of the teeth are usually involved.
b. *Salivarly citrates:* The work of Mcclue and Ruzicka suggested that erosion may be related to citrate content of saliva. But they were unable to prove this with the occurrence of erosion in human being. So this theory is not much accepted.
c. *Secreted acids:* It has also been suggested that acids from gingival cervice may cause decalcification due to lactic acidosis in the periodontal tissues. This usually occurs when there is damage due to lactic acidosis in the periodontal tissues. This usually occurs when there is damage due to traumatogenic occlusion (bruxism, interference etc.). Though erosion is not always associated with traumatogenic occlusion, the latter may be considered as a precipitating factor.
d. *Mechanical abrasion:* Also called idiopathic erosion are wedge shaped or angular defects which are similar to tooth brush abrasion. But here the predominant causative factor is heavy force in eccentric occlusion resulting in flexing (bending) of the tooth. It is further hypothesized that bending forces produce tension stresses in wedge shaped region on the tooth side away from tooth bending direction.
e. *Chelating microbial metabolic products:* The most prominent product in this is pyrophosphate and it may be contributing factor.
f. *Acid fumes:* Environmental acid fumes or workers in industries where acids are utilized may be correlated to erosive lesions. Some of these industries are painting battery manufacturer, sanitary cleanser manufactures, soft drinks manufacturer, glass workers.
g. *Excessive tensile stresses at the tooth clinical cervix:* Non-elastically deforming tooth contacts which could be premature or heavy centric, may precipitate introlerable stresses at the tooth cervix. The enamel which is knife edge at the cervix could have its prisms separated from underlying dentin, which become permeable to acid attack, which ultimately could lead to erosive lesion.
h. *Refused acids:* Chronic, frequent regurgitation as seen in Binge-Purge syndrome in bulimia or gastroesophageal reflux creates characteristic erosive lesions on lingual surfaces of anterior and posterior teeth and on the incisal edges.

Clinical Features

- These are rounded lesions with no demarcation so explore can easily pass without interruption between lesion and surrounding tooth.
- Surface of lesion is glazed.
- It usually does not affect occluding surface except in severe conditions.
- Erosion rate is same for enamel, dentin and cementum and pulp dentin organ reacts with both healthy and unhealthy reparative reaction to the erosive lesion with no effect on surrounding periodontium.

- Tooth sensitivity to physical, chemical, mechanical stimuli may be present.
- Carious lesions may occur at tooth surfaces attacked by erosion. The rate of erosion in active lesions is estimated to be 1 micron/day.

Therefore, this rarely leads to pulp exposure as secondary and tertiary dentin are usually produced at a faster rate (1.5-4 micron/day). Generalized erosion affects upper teeth more than lower teeth. Lower anterior teeth facially and upper canine and premolar facially are commonly affected. The extent of lesions may be form fine line at CEJ to substantial tooth surface loss making a hourglass shape of tooth.

Treatment

As with the other lesions, the etiological factor should first be known and measures should be taken to eliminate them or control them.

- The patient should be informed of the particular etiology and be told that any treatment is only symptomatic because if the erosive process still continues, it could even affect the restorative material.
- Study models and photographs should be made to evaluate progress of lesion or treatment if any has been provided.
- Actual height would consist of metallic restoration as they are more resistant to erosive process than non-metallic ones. Tooth colored materials which have chemico-physical bonding with tooth structure can also be used especially for hourglass shaped lesions and for lesions which are deep and may be close to the pulp. But all these may need to be replaced if erosion continues.

NON-CARIOUS LESIONS IN ENAMEL

Localized Non-hereditary Enamel Hypoplasia (Fig. 27.3)

During amelogenesis, ameloblast that are responsible for enamel, if they are injured it will result in defective formation of enamel matrix. This will ultimately result in defect is enamel which manifest as interruption or areas with no enamel at all. When the teeth erupt, these defects will be evident in the crown portion of the tooth and this is called localized non-hereditary enamel hypoplasia.

Clinical Features

Lesion range from isolated points to widespread linear defects, depressions or loss of segment in the enamel. These defective areas may be discolored as they are easily stainable. In mild cases, there may be only a few pits or fissure on the enamel surface. If condition is more severe, enamel may exhibit rows of deep pits arranged horizontally across the surface of the tooth.

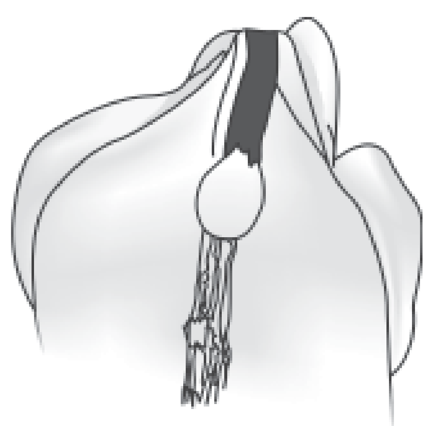


Fig. 27.3: Enamel hypoplasia

Etiology

a. *Systemic disorders:* These mainly include nutritional deficiency such as deficiencies of vitamin A and vitamin C hypocalcemia, can cause enamel hypoplasia. Certain exanthomatous diseases like measles, chickenpox, scarlet fever may lead to enamel hypoplasia. Teeth commonly affected are central incisor, lateral incisor, cuspidsand 1st molar since these are the teeth which usually from within 1 year of birth.
b. *Congenital syphilis:* Enamel hypoplasia due to syphilis is pathogenic and usually affects maxillary and mandibular incisors and 1st molars called "Hutchinson's teeth".
c. *Birth injuries:* During traumatic births, the formation of enamel may cease, causing alteration in normal enamel, forming enamel hypoplasia. In fact, the neonatal line seen in deciduous teeth and 1st permanent molar may be a type of enamel hypoplasia indicating trauma/change of environment at time of birth.
d. *Localized infection:* If a deciduous tooth becomes carious during the period when the crown of succeeding permanent tooth is being formed a bacterial infection involving the periapical tissues of deciduous tooth may affect the ameloblastic layer of permanent tooth and result in single hypoplastic tooth. This is also called as 'Tuner's tooth' or 'Tuner's hypoplasia'. This usually affects the maxillary permanent incisor or maxillary or mandibular premolar.
e. *Fluorides:* Mottled enamel—Ingestion of fluoride containing drinking water during the time of tooth formation may cause mottled enamel. The severity of mottling increased with increasing amount of fluoride in water. High concentration of fluoride, i.e. above 1 ppm affect the ameloblasts in the formative shape. Enamel hypoplasia may range from white flecks to pitting and brownish staining of enamel.

Treatment

Treatment will vary depending on the extent of hypoplasia and its location.

- If the defects are of minimum size such as isolated pits, then selective odontomy can be performed. This process consists of blending the defect with the remaining tooth structures. However, if odontomy and esthetic contouring cannot produce desirable results then veneering with composites may be done.
- In this case, surrounding enamel is conditioned by acids and resinous materials is inserted. It should be clear that acid etching of fluoride hypoplastic enamel is extremely difficult and non-conducive to efficient retention. Therefore, several application of acids may be required which can inturn harm the remaining tooth structure.
- If defect is present in the occluding areas it is necessary to resort to metallic or cast restoration, making every effort to reinforce the marginal enamel around these restorations.
- If lesions are discolored and sufficient amount of enamel is present, vital tooth bleaching of the teeth may be a treatment of choice but after selective odontomy which will remove some of the discolored areas.
- If lesion is completely disfiguring, both in color and contour and involved surface area is not an occluding one, laminated direct or indirect tooth colored resinous or ceramic veneers are treatment of

choice. When there is sufficient enamel thickness then veneer is contraindicated as it will compressive plaque control measures, cause facial disfigurement with loss of contact area. In such cases PFM or cast ceramic full veneering restorations are recommended.

Localized Non-hereditary Enamel Hypocalcification

These are defects of the enamel, which are ectodermal in origin. These usually occur when ameloblasts are injured during mineralization of enamel. If mineralization of enamel matrix is affected in the calcification stage, it leads to non-hereditary enamel hypocalcification.

Clinical Features

The affected teeth will have enamel which is very soft and can be easily removed with a prophylaxis instrument. These areas are chalky and can be easily stained. The shades of teeth may range from chalky to yellow to brown, dark brown and/or grayish. If extensive, these lesions may predispose to attrition or abrasion. Also the enamel can be chipped if the lesion involves entire surface of tooth.

Treatment

- Initially, no treatment such as bleaching, veneering, odontomy should be carried out.
- If diagnosed early, when the enamel is still intact, mineralization process should be initiated. This procedure can be done using periodic fluoride application, fluoride ionophoresis, strict prevention of plaque accumulation. In some cases mineralization can occur to some extent.
- In other cases, composite veneering, bleaching, laminated veneering, PFM crowns or all ceramic crowns can be treatment of choice.

Amelogenesis Imperfecta

Syn. Hereditary enamel hypoplasia, hereditary brown enamel, hereditary brown opalscent teeth.

Amelogenesis imprefecta (AI) represents a group of hereditary defects of enamel unassociated with any other generalized defects. These defects are unassociated with evidence of biochemical or systemic disease. They may be autosomal dominant tracts (hypocalcification, localized hypolasia) or X-linked trait (hypomaturation) or recessive trait (pigmented hypomaturation).

Depending on this, 3 basic types of amelogenesis imperfecta are recognized. These are:

a. Hypoplastic type—in which there is defective formation of enamel matrix
b. Hypocalcific type—in which there is defective mineralization of formed matrix.
c. Hypomaturation type—in which enamel crystallites remain immature.

Clinical Features

Amelogenesis imperfecta affects only one type of dentition and only the enamel as it is an ectodermal disturbance.

In hypoplastic type:
- This enamel, open contact
- Small teeth with short roots, very limited pulp chamber and root canal dimensions
- Delayed eruption of teeth
- Sometimes enamel has glassy appearance due to lack of prisms
- Enamel may be discolored, wrinkled or yellow with signs of severe occlusal wear.

In Hypocalcific type:
- Enamel is usually stained yellow or black. It may be chalky in early stages of life.
- Enamel is soft in consistency and chips away easily.
- Enamel gets worn away easily.

In hypomaturation:
- Enamel can be pierced by an explore point under firm pressure and can be lost away by chipping from underlying normal appearing dentin.

Radiographic Features

Enamel may be totally absent on radiograph and when present may appear as a very thin layer, only over cusp tips or interproximal surface. In cases of hypocalcification, density of enamel and dentin may appear same on radiograph.

Treatment

Early diagnosis is a key to relatively successful treatment.
- Selective odontomy or esthetically reshaping the teeth. This may need to be repeated throughout lifetime of the tooth due to various changes in shape (attrition).
- Full veneering—this will include procedure with metallic, metallic based or cast ceramic restorations. These should not be opposing natural tooth. In such cases, opposing should also be restored with similar materials.
- Periodic evaluation is necessary to determine outcome of treatment.

NON-CARIOUS LESIONS OF DENTIN

Localized Non-hereditary Dentin Hypoplasia

Differentiation of cells of odontoblast result in formation of the dentin. odontoblasts are very specialized cells. Their function can be disturbed by environmental irritation, leading to deficient or complete absence of dentin deposition. But unlike ameloblasts which are irreplaceable cells, odontoblast are replaceable cells. If ameloblasts are damaged, it means no enamel in that area. But in odontoblasts, there will be no dentin temporarily but dentin deposition will be resumed as soon as othe cells of pulp start depositing it. In these cases, defect will be isolated with in the dentin substance. This situation does not require any treatment.

Such defects may go unnoticed ever during cavity preparations for restoration. However, if these defects are sizeable and exposed during cavity preparation, treatment will consist of intermediary basing to bring the pulpal floor at same level and help restoration.

Localized Non-hereditary Dentin Hypocalcification

In certain cases, during the formative stage, if odontoblasts are disturbed it may result in total absence or faulty deposition of dentin. if dentin matrix is deposited and fails to calcify it will result in localized dentin hypocalcification.

Dentin in such cases will be soft, easily penetrable and less resilient. The most common example of this is interglobular dentin. Most of the time lesion is unnoticed even when uncovered by cavity preparation. In cases of severe involvement, treatment would consist of removal of defect followed by intermediary basing prior to permanent restoration.

Dentinogenesis Imperfecta (Fig. 27.4)

Syn: Hereditary Opalscent Dentin:

These are genetically dictated classes of disease, of mesodermal origin, affecting the

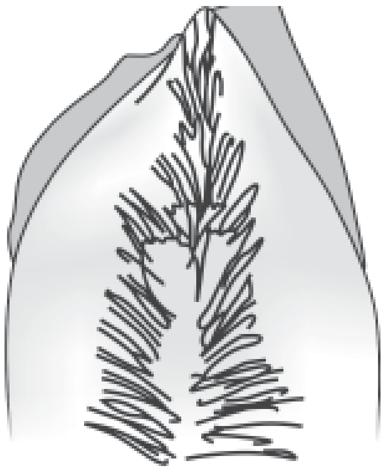


Fig. 27.4: Dentinogenesis imperfecta

formation, and/or maturation of dentin matrix in absence of obvious systemic or biochemical change. They are basically autosomonal dominant trait. There are several classification for dentinogenesis imperfecta based on clinical features, or association with osteogenesis imperfecta or according to extent.

According to association with osteogenesis imperfecta, they are classified as:

Type I - Dentinogenesis imperfecta which is always associated with osteogenesis imperfecta

Type II - Dentinogenesis imperfecta which never occurs with osteogenesis imperfecta

Type III - Dentinogenesis imperfecta of 'Brandywine type'. These mostly affect the deciduous teeth.

Type II and III affect both the dentitions.

Clinical Features

Color of teeth may range from grey to brownish violet to yellowish brown but they exhibit a characterized unusual translucency or opalscent hue.

- Definite abnormality of DEJ is present. The scalloping of DEJ is absent, therefore enamel though unaffected can get easily chipped. With early loss of enamel, dentin undergoes rapid attrition.
- Crowns are over contoured. Roots are short slender.
- Severe attrition may be present. Dentin is without tubules.
- Dentin will contain lot of interglobular dentin.
- Root canal and pulp chamber space is obliterated.
- Dentin hardness and resilience is half that of normal dentin.
- Decay if initiated, spreads laterally.

Radiographic Features

- For types I and II striking feature is partial or complete obliteration of pulp chamber and root canal with continued formation of dentin which is seen in both deciduous and permanent teeth. Teeth are smaller but cementum, periodontal ligament and alveolar bone are normal.
- For type III there are appearance of shell teeth. Enamel of normal thickness, but dentin is very thin with enormous pulp chamber. This is basically due to insufficient formation of dentin.

Treatment

- Treatment is directed mainly towards preventing loss of enamel and subsequent loss of dentin through attrition. Two treatment selective odontomy and permanent full veneering procedures.
- As the teeth are very weak, permanent full cast crown should be given. There should not be any attempt to use intracanal or intraradicular retention modes. Therefore, only retention possible

and reliable is extracoronal reinforcing protecting veneering restoration.
- Splinting between teeth may be considered to avoid root fracture.

Dentinal Sclerosis (Fig. 27.5)

Syn. Transparent Dentin:
Odontobalsts are highly specialized, delicate and easily irritable cells. So when there is mild irritation to the dentin, the odontoblasts promote the formation of peritubular dentin peripherally. Such peritubular dentin is highly calcified as compared to intertubular dentin matrix and is called dentinal sclecosis. Though, it occurs usually due to caries or abrasion it can also be a manifestation of normal aging process. These can be recognized due to difference in refractive indices between sclerotic of calcified dentinal tubules and adjacent normal tubules.

The exact mechanism of dentinal sclerosis or deposition of calcium salts in the tubule is not understood, but most likely source of calcium salts is the fluid or dental lymph with in the tubules. Sclerotic dentin reduces the conductivity of odontoblastic process and slows advancing carious lesion.

According to Hodge and Mckay, sclerotic dentin is harder and highly calcified than normal dentin.

Irritation Dentin

Syn: Irregular dentin, reparative dentin, secondary dentin, calcific barrier, adventitious dentin.

Secondary dentin (Fig. 27.6) which is formed after the deposition of primary dentin can be physiologic if it is associated with aging process. It can be pathologic if it results from stimulation of exposed dentinal tubules and odontoblastic processes in situation such as attrition, abrasion, erosion, tooth fracture, cavity preparation.

According to Ingle, term 'irritation' is more appropriate than reparative. Term reparative can be misleading, indicating healing or repair which is not true. For example, in case of trauma or subluxation, blood supply can be temporarily disrupted, causing degeneration of odontoblastic process and their subsequent replacement. New cells arise and align themselves along the predentin and rapidly form irregular hard tissue called irritation dentin. A line can be declinated between old

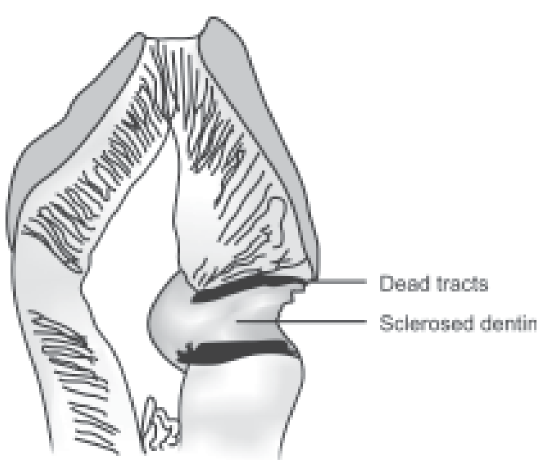


Fig. 27.5: Dentinal sclerosis

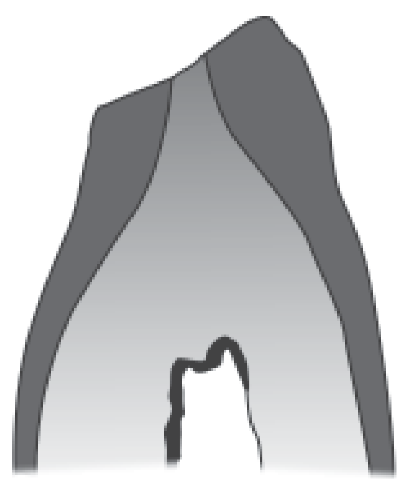


Fig. 27.6: Secondary dentin

and new altered hand tissue called 'calcico-traumatic line' or 'resting line'. These new cells do not have inhibitory regulation of normal odontoblasts and thus continue to form irritation dentin until there is complete obliteration of pulp chamber called 'calcific metamorphosis'.

Tertiary dentin form when pulp irritants are more intense and are present for prolonged periods of time. They can be differed from secondary dentin in that it is localized exclusively adjacent to the irritated zone. Secondary dentin forms in response to slight aggressive effects of normal biologic function.

Clinical Features

There is evident decreased in tooth sensitivity when secondary dentin formation is extensive. This forms an insulating layer between pulp and particular pathologic process, thus delaying pulp involvement.

It can also occur in deciduous dentition. Anterior teeth have higher incidence of secondary dentin formation than posterior teeth.

Dead Tracts

When irritation to dentin is continued for prolonged periods, odontoblasts completely degenerates leading their protoplasmic fibers in the dentinal tubules. As these fibers degenerate, dead tract is formed.

The dead tract was previously thought to be a defensive mechanism as it was believed to be inprevious to irritating agents. However, it is now known that dead tracts are more permeable to chemicals and toxins. Also, dead tracts deprive dentin of their elastically, which is important for restorative procedures.

'Dead tracts' in dentin are manifested as black zone by transmitted light but as white zone in reflected light. This is due to difference in refractive indices of affected tubules and normal tubules.

NON-CARIOUS LESIONS OF CEMENTUM

Hypercementosis (Fig. 27.7) Syn: Cementum Hyperplasia

Hypercementosis may be regarded as a regressive change of the teeth characterized by deposition of excessive amounts of secondary cementum on root surfaces. Although it can involve entire root area, it is usually focal, occurring only at the apex of the tooth.

Etiology

a. Acclerated elongation of tooth: Loss of antagonist is accompanied by hyperplasia of cementum apparently as an inherent tendency to maintain normal width of periodontal ligament. This is most common at the apex of the root.
b. Inflammation about the tooth: Inflammation at the apex of the tooth as a result of pulpal infection sometimes stimulates excessive deposition of cementum.

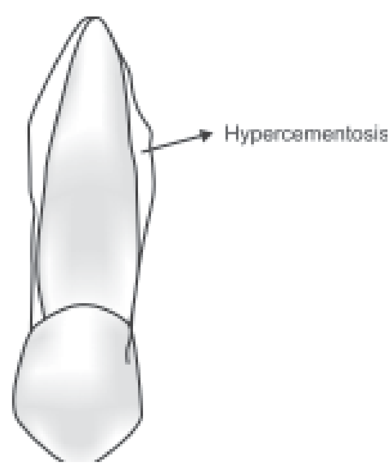


Fig. 27.7: Hypercementosis

Hyperplasia of cementum does not occur at apex as this is resorbed due to inflammatory process, but will occur some distance above the apex, which may act as stimulus for cementoblasts.

c. Tooth repair: Tooth repair does not cause deposition of large amounts of cementum, but cementum is laid down with such rapidity that a mild form of hyper-cementosis is stimulated.

Occlusal trauma results is mild root resorption which is repaired by secondary cementum. Root fracture is also repaired by deposition of cementum. Finally, cemental tears are repaired by cementum growing and filling the defects.

d. Osteitis deformans or Paget's disease of bone: This is a generalized skeletal disease characterized by deposition of excessive amounts of secondary cementum on roots of teeth and by apparent disappearance of lamina dura of teeth.

Spike formation of cementum is uncommon condition characterized by occurrence of small spikes or outgrowth of cementum on the root surface. These cemental spikes occur in cases of excessive occlusal trauma.

Radiograph Features

There is thickening and apparent blunting of roots. The roots loose their typical sharpened or spiked appearance and exhibit rounding of apices. The cementum deposited is also called ostocementum due to its close resemblance to bone.

Treatment is not necessary.

Cementicles (Fig. 27.8)

Cementicles are small foci of calcified tissue, which lie free in the periodontal ligament of the lateral and apical root areas. Their exact cause is unknown, but represent areas of dystrophic calcification and these are examples regressive change.

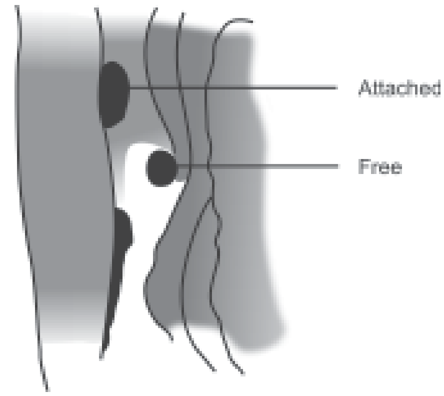


Fig. 27.8: Cementicle

The most common manner in which cementicles develop is by calcification of nests of epithelial cells, i.e. epithelial rests in the periodontal ligament. These bodies enlarge by further deposition of calcium salts in adjacent surrounding connective tissue. This continued enlargement may result in fusion of cementicle with root cementum or alveolar bone. They may also arise with in the Sharpey's bundle.

Small spicules of cementum torn from the root surface called cemental tears lie free in periodontal ligament and resemble cementicle.

Finally, cementicles appear to arise through calcification of thrombosed capillar-ies in PDL. They are very small, i.e. 0.2-0.3 mm and are seldom seen on radiograph. Clusters of cementicles at apex of teeth have been regarded as cementomos. Cementicles are of no clinical significance and are not determiecual to tooth function.

PULP CALCIFICATION

Basically there are two chief form of pulp calcification:

1. Pulp stones (denticles, pulp nodules)
2. Diffuse calcification

Pulp stones are commonly seen in coronal pulp and diffuse calcification are commonly seen in radicular pulp.

Pulp Stones

These are discrete calcific masses which occur in increasing frequency in mature teeth. But they can also be seen in young teeth.

They can be classified as:
- i. True denticle
- ii. False denticle

i. *True denticle:* These are localized masses of calcified tissue that resemble dentin because of their tubular structure. They resemble more like secondary dentin since tubules are irregular and fewer in number.

ii. *False denticle:* These are composed of localized masses of calcified material and do not exhibit dentinal tubules. They are found of connective layers of calcified tissues on a matrix that seems to consist primarily of collagen which acquires collagen. The possibility of false pulp stone may be in blood vessels and nerves, calcification of thrombi in vessels or calcification of clumps of necrotic cells.

Based on the location, pulp stones can be classified as:

a. Free pulp stones: When denticles are lying entirely with in the pulp tissue and are not attached to dentinal walls, they are called free denticles.
b. Attached pulp stones: When pulp stones are continuous with dentinal walls, they are attached denticles.
c. Embedded pulp stones: These are those pulp stones which were attached, but are now totally surrounded by dentin.
d. Interstitial denticle: False pulp stones which on growing has become continuous with dentinal wall and completely surrounded by it is called 'interstitial denticle'.

Diffuse Calcification

Syn: Linear calcification, calcific degeneration These are tiny calcified spicules which have longitudinal orientation and are located in radicular pulp. Its usual pattern is in amorphous unorganized strands or columns paralleling the blood vessels and nerves of pulp. Like pulp stones, these tend to increase with age and with irritation.

Dystrophic Calcification

These are usually seen in pulp of the teeth of older persons or in young persons in teeth having undergone trauma.

They may occur in the wall of the blood vessels or in the peripheral connective tissue of pulp. They may appear as fine, scattered fibrillar calcification which may coalesce to form long masses of calcific material.

They can be of two types:

a. Nondular type: This is the result of calcification of hyalinized connective tissue. Such calcification is usually perivascular or perineural and is often associated with increased fibrosis. The calcium deposit are a frequently found in coronal portion of pulp chamber and increase in size by calcium deposition around collagenous fibrils.
b. The second type of calcification of pulp is that found in and around necrotic cells and corpora maylacea. It occurs in a multicentric manner. This type shows nidus in center which increase in size by concrescence.

TRAUMA

Separation and/or loss of tooth structure as a result of trauma frequently occurs necessitating dental treatment.

Trauma that leads to these mishaps can be from substantial impact forces, as from a fall, flow or sudden biting on a hard unyielding substance. Trauma can also result from long standing cyclic loading forces that occurs over a long period of time and can result in periodontal break down, in addition to tooth fracture or cracking. Such cyclic, non-physiologic loading always results from occlusal influences, especially the balancing type.

Classification

According to Ellis, fracture can be classified as:

CI I - Simple fracture of tooth crown, involving only enamel.

CI II - Extensive fracture of tooth crown, involving dentin but no pulp

CI III - Extensive fracture of crown, involving considerable dentin and exposing the pulp

CI IV - A traumatized tooth which has no become non-vital with or without loss of crown structure

CI V - Tooth lost as a result of trauma

CI VI - Fracture of tooth root, with or without loss of crown

CI VII - Displacement of tooth, without fracture of crown or root

CI VIII - Fracture of crown enmasse, with broken pieces irretrievable

CI IX - Incomplete fracture of tooth or cracked tooth

CI X - Cyclic incomplete discoloration of tooth.

WHO Classification

873-60 Enamel Fracture: Involves enamel only including enamel chipping and incomplete fracture cracks also called as crown infractions.

873-61 Crown fracture without pulp involvement - fracture consisting of enamel and dentin only.

873-62 Crown fracture with pulpal involvement - complicated fracture involving enamel, dentin and pulp

873-63 Root fracture limited to fracture involving root only; cementum, dentin, and pulp.

873-64 Crown - Root fracture - involving enamel dentin and cementum without or with pulp exposure.

873-65 Tooth luxation (dislocation) - This category comprises of concussion, subluxation and luxation. Concussion refers to injury where tooth is sensitive to percussion but is not loosened or displaced. Subluxation refers to loosening without displacement. These luxation injuries are usually accompanied by fracture or commination (fragmentation) of alveolar socket.

873-67 Intrusion or Extrusion. Instruction is displacement of tooth in the alveolar bone and is accompanied by fracture of alveolar socket. Extrusion is partial displacement of tooth out of the socket.

873-68 Avulsion - also referred to as extra articulation or complete displacement of tooth out of the socket.

873-69 Other injuries - includes laceration of soft tissues or oral cavity.

Treatment

There are three therapeutic bases for treatment of traumatized teeth.

1. Accurate and detailed examination of the injury should be done and recorded. Through examination of the soft tissues, i.e. oral and paraoral tissues should be recorded and be taken into consideration during therapy. In addition data on status of root condition and development is necessary.
2. The patient should be made aware of the fact that vitality of the tooth at the time of examination does not mean that the tooth will be vital by end of treatment, as traumatized injury may be a start of degenerative process in the periodontal organ that can lead to immediate or delayed pulp necrosis.
3. Sometimes due to incomplete tooth development and/or the extent of tooth involvement or early stage of passive tooth eruption when the accidental defect occurred, tooth will need two sets of restorative modalities. First is the provisional restoration until development is complete or passive eruption is stabilized and second one is the permanent restoration.

Based on this treatment will differ for each category of fracture.

1. Enamel fracture
   a. Smoothening the edges and peripheries of the defect is sufficient in most cases.
   b. Esthetic reshaping of the involved area and similar areas on symmetrical teeth may be necessary.
   c. It defect involves a large surface area that cannot be corrected by above mention method, then areas has to be restored with composite resin using acid etch technique.

   Finally, one important consideration is to check pulp vitality immediately and again after 6-8 weeks because even in minor trauma cases, injury to apical neurocascular bundle may have occurred.
2. Crown fracture without pulp involvement (also called uncomplicated crown fractures).
   The primary consideration is such fracture should be given to extent of fracture, i.e. proximity of the fracture to pulp. In cases of close proximity to pulp but without exposure pulp protection by sealing the dentinal tubules is important. The most effective methods is by direct application of Ca(OH)2 such as Dycal. Then fracture site has to be covered and consideration given to function and esthetics. This is done by using acid - etching composite resin.
   Occasionally if fractured tooth fragment is found it can be bonded to the crown of tooth give very good esthetic restoration. Early treatment is important as it can have adverse effect on pulp's vitality to survive. Again, pulp vitality should be checked periodically.
3. Crown fracture with pulp involvement (complicated crown fractures)
   Treatment planning in such cases is influenced by tooth maturity and extent of fracture. Every effort must be made to preserve pulp of immature teeth. Conversely in mature teeth with extensive loss of tooth structure, pulp extirpation and RCT are prudent before any permanent restoration.
   Pulp preservation by vital pulp therapy, especially of immature teeth includes pulp capping and pulpotomy. Both procedures

permit preservation of pulp tissue for continued root development. In recent years, a modified pulpotomy technique known as 'shallow pulpotomy' or 'partial pulpotomy' is considered to be more predictable. This present method is incontrast to older method which was 'deep pulpotomy' in which there was complete removal of coronal pulp cervical to the deeper level. This technique was difficult and failed to preserve vitality because of removal of tissue in the critical cervical area.

In shallow pulpotomy, first granulation tissue is removed and exposure site observed and then pulp tissue in the pulp chamber is removed to a depth of 1-2 mm with round diamond stone with sufficient water coolant. This area is then covered with light cured $Ca(OH)_2$ and ZOE or zinc phosphate filling. This is later replaced with composite resin.

In mature, fully formed teeth, nonsurgical RCT with full coverage crown is treatment of choice.

Pulp capping can be accomplished only in those cases in which treated segment can be resorted with use of bonded composite resin.

According to studies by Herde and Eveli, pulpotonies immature teeth can be performed maximum up to first week post fracture and in immature teeth more than 1 week post fracture could allow root development.

Root Fracture

These can be horizontal or vertical root fractures. If fracture is horizontal then it can be:

- Cervically horizontal
- Midradicularly horizontal
- Apically horizontal

Cervically horizontal: In most cases coronal fragment will be mobile. Therefore, treatment will consist of repositioning the coronal segment and then rigidly splint the tooth to adjacent teeth to promote repair. Reduction of the fracture can be done by finger pressure or orthodontic intervention. If considerable time has elapsed it is difficult to reduce the fracture.

If the coronal fragment is too close to the crestal bone, then removal of fragment which periodontal surgery, intentional extrusion may be necessary.

Mid-radicularly horizontal: If tooth vitality is present, immobilization should be done by splinting for at least 12 weeks. This relatively long stabilization period will allow calcific barrier to be formed at fracture site, both externally and internally.

If tooth becomes non-vital, RCT should be carried out after splinting.

Apically horizontal: If in the apical third, and no mobility is present and tooth is vital no treatment is necessary though periodic recalls to check vitality should be done. If non-vital then root canal therapy can be carried out and apical root fragment can be surgically removed.

Healing of root fracture as can be one of the 4 methods:

1. Healing with calcified tissue: Radiographically fracture line is discernible but fracture fragments are in close contact.
2. Healing with interproximal connective tissue: Radiographically fragments appear separated by numerous radiolucent lines and edges are rounded.
3. Healing with interproximal bone and connective tissue: Radiographically fragments are separated by distinct bony ridge.
4. Interproximal inflammatory tissues without healing - radiographically a

widening of the fracture line and/or developing radiolucency corresponding to fracture line becomes apparent.

In case, root fractures do not heal following can be done:

a. RCT of both coronal and apical segment if fracture is close and allow passage of the from coronal segment to apical segment.
b. RCT of coronal segment and removal of apical segment if non-healing is present with radiolucency.
c. RCT of coronal segment and no treatment of apical one.
d. Intraradicular splint recommended by wires. After endodontic therapy of both coronal and apical segment, post space is prepared extending from coronal to apical segment and then rigid post is placed (vitalum Cr-Co) to stabilize two root segment.

Vertical Root Fractures

This is extremely difficult to diagnose. Only through symptoms of isolated periodontal pocketing next to fracture line, non-vitality of tooth, loose retrograde filling or reflecting mucogingival flap can this be recognized.

Vertical root fracture has a very poor prognosis as it always propagates quickly to the tooth crown, thereby connecting periodontium and pulp root canal tissue with infected oral environment. Therefore, treatment is extraction of single rooted teeth and hemisectioning or partial amputation of multirooted teeth.

Crown Root Fracture

If they involve the pulp, then previously mentioned procedures are to be carried out. If fracture is within 4 mm of gingival crest then gingivectomy, alveolectomy or intentional extrusion can be carried out.

Another suggestion for fracture below gingival crest is intercanal reimplantation with extrusion. After RCT, it can be restored to normal condition and appearance.

Avulsion

Tooth is reimplanted into the socket and splinted with adjacent teeth.

Enamel Cracking

There are several reason for incomplete tooth fracture. These are:

a. Premature occluding contacts especially in lateral mandibular excursions.
b. Very deep and wide intracoronal restoration.
c. Disclusion mechanism including posterior teeth.
d. Forced in retention modes of restorations e.g. pin, cements etc.
e. Posterior teeth cusp inclines being very steep.
f. Hyper mineralization and dehydration of tooth structures.
g. Habits (bruxism)

Diagnosis

- Spontaneous pain especially on chewing as it usually affects the posterior teeth in order of second lower molar, first lower molar, maxillary premolars, other teeth are seldom affected.
- Applying pressure on wood stick or rubber wheel, mirror handle can elicits pain on that tooth.
- If amalgam restoration is present corrosion products can stain the crack.
- Transillumination, fiberoptic or in condescent light can show crack.
- Coloring dyes like methylene blue or mercurochone can show crack.
- Sometimes radiographs can also reveal a crack in sound tooth.

Treatment

- Relieve the tooth from eccentric occluding contacts.
- Cement band circumferentially around the tooth (othodontic or copper band).
- If signs of pulpitis persist after above treatment proceed with endodontic treatment.
- If tooth contains large intracoronal restoration it should be removed and filled with temporary for few days.
- After these, permanent restoration will be in form of cast restoration which reinforce the intracoronal restoration.

Teeth Fracture due to Cyclic Loading

To adequately treat this cyclic incomplete dislocation, the extent and cause of periodontal breakdown should be detected. From this periodontal therapy should be instituted which will include occlusal equilibrium.

After this tooth needs to be immobilized for a while to enhance periodontal healing. This immobilization is done after reducing the tooth to its physiologic position.

RESORPTION (FIG. 27.9)

Any radiologic defect visible on the root that is not caused by caries must be the result of resorptive process of some kind. More different is the pathologic interpretation. Two possibilities exist: either the resorption originated from the pulp and progressed outward or it originated in the periodontal membrane and invaded the pulp chamber from without.

Based on these factors are the following definition:

Resorption: A condition associated with either physiologic or pathologic process which results in loss of substance from a tissue, such as dentin, cementum or alveolar bone.

Root resorption: Resorption affecting the cementum and/or dentin of root of a tooth. Based on the site it may be internal, external or root end resorption.

Idiopathic resorption: Resorption that occurs without any apparent cause. Teeth commonly involved are maxillary cuspids.

Internal resorption: Type of tooth resorption initiated with in the pulp cavity when resorption occurs within the crown of the tooth and reaches the enamel, a pink spot may be seen.

Internal Resorption (Fig. 27.9)

Internal resorption occurring within the tooth, can affect one tooth or many teeth. Incisors show highest incidence, however, it is also seen in posterior teeth.

Etiology

Though any specific etiology for internal resorption has not been given, it can occur due to several factors:
- Trauma, 2% incidence following luxation injuries, have been suggested.
- Chronic irreversible pulpitis
- Vital root resection
- $Ca(OH)_2$ pulpotomy

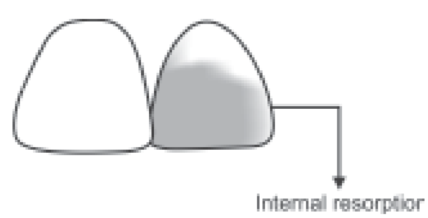


Fig. 27.9: Internal resorption

- Application of diathermy
- Anachoresis
- Orthodontic tooth movement

  Several theories have been suggested for actual mechanism of resorption. Resorption develops in following sequence of events.
- Sudden trauma to the tooth produces intrapulpal hemmorage
- Internal resorption is proceeded by disappearance of odontoblasts and pulpal incurasion of macropahge like cells
- At the same time, hemorrhage organizes and it is replaced by a granulation tissue.
- The proliferating granulation tissue compresses the dentin walls, predentin formation cases, odontoblasts differentiate from the connective tissue and resorption begin.
- Necrosis of pulp may occur as destruction becomes extensive and pulp communicates with oral fluids after perforation of the root or crown surface.

SEM study has revealed organic material and microorganism like structures in a resorbed root. Concomitant with resorption of hard tissue is frequent deposition of a hard tissue like bone or cementum. These resultant structure bear no resemblance with normal tooth and are termed as 'metaplastic' tissue.

It has also been postulated that a traumatic episode or any electrical activity such as Peizo electricity causes active hypernemia with high O_2 pressure which supports and induces osteoclasic activity.

Heithersay postulated that internal resorption may be the effect of a collateral blood supply via an interconnecting and large lateral accessory canal. This would provide sufficient vascular bed for resorptive process to occurs. This is most commonly seen in endodontically treated teeth.

Clinical Features

Internal resorption is usually asymptomatic and seen on routine examination of radiographs. Supplemental radiographs taken from different horizontal angulations will aid in diagnosis. If resorption defects does not change position in comparisons to radiographs and is within the confines of root, it is internal resorption. Also if it is superimposed on the canal, then canal will show an enlarged area and will not be present in area of the lesion.

Pain may occur when there is perforation of crown or root with formation of a periodontal lesion. Internal resorption may be rapid or it may take years. The resorption areas will have smooth margins.

Treatment

Three types of treatment of internal root resorption are present depending on sensitivity.

a. Non-surgical when resorption does not perforate canal wall and endodontic treatment can be carried out by non-surgical approach which is treatment of choice.
b. Recalcification with $Ca(OH)_2$ if there is perforation of canals wall apical to epithelial attachment $Ca(OH)_2$ technique can be used. $Ca(OH)_2$ mixed with anesthetic solution is placed in area of resorption along the walls of canal to stimulate a hard tissue barrier formation. This is done after apical canal preparation. $Ca(OH)_2$ is changed every 6 weeks of 3 months internal depending on sensitivity. Repair may be observed as early a 6 months postoperative or as late as 20 months.

c. Surgical- when there is extensive root destruction or uncontrollable bleeding and perforation is coronal to epithelial attachment a surgical treatment or sometimes extraction may be needed.

Surgical

After access is obtained canal is prepared in the apical portion upto the defect, when dry field is obtained, this is obturated with lateral condensation gutta percha. The remainder of canal is filled with vertical condensation technique. Considerable bleeding is usually encountered when highly vascularized mass of granulation tissue is uncovered. Irrigatin with 5.25% NaOCl and vasoconstrictors will assist in controlling the hemmorage. All granulation tissue should be removed.

Tooth should be reinforced with post to double the resistance to treatment. Surgical treatment may be necessary if the non-surgical or $Ca(OH)_2$ technique is unsuccessful when uncontrolled bleeding is present from perforation defect, perforation is near of at the epithelial attachment. If resorption is in the apical 1/3rd, root resection coronal to the defect should be employed. An endodontic implant has been suggested when there is extensive root destruction in middle or apical third of the root.

External Resorption

Etiology

Shafer et al designated the following factors:

- Periapical inflammation
- Excessive mechanical or occlusal forces
- Reimplantation of teeth
- Impaction of the teeth
- Radiation therapy
- Non-vital tooth bleaching
- Galvanic corrosion of non-precious posts
- Hyperparathyroidsm, calcinosis, i.e. systemic causes - usually occurs at apex of several teeth and bilateral
- Periodontal defects
- Idiopathic

External resorption of primary teeth during the eruption of their permanent successors is considered physiologic. Three separate phases are described: active, partial and reparative. Some amount of external resorption has found to occur in normal healthy teeth.

Cervical Resorption

External resorption in the coronal third of the root near the CEJ is usually the result of an inflammatory reaction in the surrounding tissues, the periodontal ligament. It may be due to traumatic episode, in the replantation of teeth, anylosed teeth or luxated teeth. Cervical resorption may undermine the crown. It has been shown that certain cervical resorption may surround pulp chamber and root canal but not penetrate it. Odontoblastic layer of underlying predentin seems to act as barrier against resorption. In advanced stages it may create a classic 'pink spot', which has to be differentiated from 'pink spot' in internal resorption.

Frank calls external cervical resorption as extracanal invasive resorption. (Syn) Internal replacement, asymmetrical internal, progressive intradental, pulpal cervical, cervical external. It surrounds the pulp chamber and root canal without invading it. Pulp space is separated from the resorptive areas by a resisting dentin shell. This may be because classic osteoclastic cells generally attack well calcified structures such as bone dentin, cementum, however, pulp is surrounded by uncalcified predentin which is not readily amenable to cellular classic action.

They are of two types:

Type 1. Supraosseous: These are open lesions at or beneath the gingival sulcus. In addition, resorption may break into the pulp chamber and a pink tooth may result.

Type 2. Intraosseous: Extracanal invasive resorption is characterized radiographically as having an irregular mouth eaten appearance with in the tooth and is more advanced and more radiolucent. But on close examination canal can be traced through the lesion. Pulp tests are vital and are a symptomatic, etiology - injury, orthodontic tooth movement. Diagnostic off angle mesial and distal radiographs will move lesions, a canal can be traced in the lesion.

Apical external resorption: apex may be slightly blunted to grossly resorbed caused by pressure from orthodontic movement. Root may be obliquely resorbed or have a cupped out appearance or chewed appearance.

Treatment modalities depend on level of epithelial attachment. When resorption is apical to epithelial attachment then calcification should be attempted. RCT therapy with sealing of resorption from outside is to be done. Finally, tooth should be reinforced with posts. If at the level then surgical treatment is indicated.

Cervical resorption can also due to bleaching. Preventive measure should be taken for the same.

- Barrier placement
- Avoid using heat
- Avoid etching dentin
- Beware of caustic nature of surperoxol

Lateral Resorption

External resorption on the lateral aspect of the root appears to be a due to luxation injury especially intrusive trauma. This is mainly due to crushing of periodontal ligament.

Non-perforating Lateral Resorption

When lateral external resorption does not perforate the root canal, non-surgical RCT can stop the destruction.

Perforating Lateral Resorption

When lateral resorption reaches the dentin or perforates the root canal, the $Ca(OH)_2$ dressing should be changed every 3 months until barrier is formed. If barrier is not formed with in 24-30 months a surgical approach should be used.

Resorption following Replantation of Teeth

Root resorption following replantation of avulsed teeth is a postoperative response that must be anticipated. Andersen classified 3 types of periodontal reaction following replantation.

- Healing with normal periodontal ligament
- Replacement resorption
- Inflammatory resorption

Healing with normal periodontal: Such cases can be said to be successful. Tooth will be stable and asymptomatic, gingiva is free of inflammation. Small areas of the root surface may show superficial resorption lacunae repaired by cementum. This condition is termed surface resorption. It is self-limiting and show spontaneous repair.

Replacement resorption: Conditions is which root is resorbed and alveolar bone is replaced in its place is called replacement resorption. This phenomenon is usually seen with 1 year of reimplantation. The tooth will be in infra- occlusion and dull sound on tapping is present. Tooth not reimplant within 2 week of evulsion can be expected to fall in this categories.

Inflammatory resorption: They are bowl shaped resorptive areas, rapidly progressive roots which are replaced by inflammatory cells in periodontal ligament. Institution of RCT will halt the resorptive process PDL will contain inflammatory cells line plasma cells, lymphocytes, PMN leukocytes in granulation tissue. If treatment is not initiated tooth may become mobile. These can be seen laterally and apically.

CONCLUSION

Non-carious lesions from 25% of the total tooth destruction. Therefore, accurate diagnosis and implementation of the correct treatment are necessary, for example, attrition, abrasion, erosion, are three separate and distinct processes each of which results is loss of tooth substance but the terms are used interchangeably. Such careless terminology serves only to confuse the recognition of etiology and to delay institution of proper treatment.

Therefore, it is required of the operative dentist to correctly diagnosis and treat such lesion.

28A Wedge and Instrument Grasp

DEFINITION

It is a piece of soft wood or a plastic which is used to support and adapt the matrix band against the tooth.

Objectives of using a Wedge

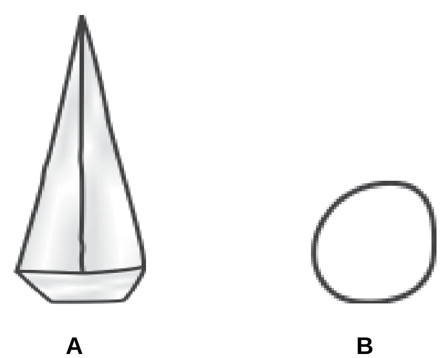
1. To support the band till the material set
2. To contour the band.
3. To push the band against the tooth
4. Prevent the overhang of restoration.
5. To push the free gingiva down or apically to prevent injury
6. To absorb the moisture so that any contamination of reservation of cavity is prevented.
   This can be:
   i. Round—Non-anatomical
   ii. Triangular—Anatomical
   Health gingiva used Wedge
   Receding gingival used round wedges
   Classification (Fig. 28A.1)
   1. Anatomical – Round
   2. Non-anatomical – triangular
      - Plastic
      - Wooden

Wedging System

1. Single wedging system—If contact is more lingually placed than place single wedges on buccal side and vice versa.
2. Horizontal wedging system—If gingiva is healthy then two wedges (one buccally one lingually) placed horizontally.
3. Piggy back wedging—If gingiva migration then place one a wedge (base of above and other wedge placed above it).
4. Double wedging—If mesiodistal gap between two teeth is more than one wedge mesially. Mesiobuccal and other distally lingually or vice versa. Placed horizontally.
   Length of wedges : 8 mm to 1 cm.
   Too small : Difficult to hold
   Too large : Injure the surrounding tissue.

Instrument Grasp

There are 4 grasps used for hand instruments:
1. Modified pen grasp
2. Inverted pen grasp



Figs 28A.1A and B: Wedge and instrument grasp: (A) Non-anatomical wedge (B) Anatomical wedge

3. Palm and thumb grasp
4. Modified palm and thumb grasp

Modified pen grasp: This grasp permits greatest delicacy of touch. This allows application of considerable face with very accurate control.

Pads of the thumb, index and middle finger contacts the instrument while the tip of the ring finger and little finger is placed of the nearby tooth surface of the same arch as rest. The pulp of the hand is generally facing away from the operator. The pad of the middle finger is placed near the topside of the instrument and forces applied to the instrument.

The application of forces is near the working point of the instrument.

Inverted pen grasp: The finger portion is similar to that of modified pen grasp but the hand is rotated so that the palm faces the operator. It is used mostly in the upper especially the lingual aspect of anteriors.

Palm and thumb grasp: This is like holding a knife while peeling the skin from an apple. The handle is placed in the palm of the hand and grasped by all the four fingers. With the thumb resting on the nearby tooth of the same arch or on a static structure.

It may be useful in maxillary teeth particularly the right side when working from the right rear portion.

This form of grasp is usually necessary where the rest support for the thumb is at some distance from the point of operation.

Modified palm and thumb grasp: This is used when there is facility to rest the thumb on the tooth being prepared or the adjacent tooth.

The handle of the instrument is held in all the four fingers where pads from the handle against the distal area of the palm as well as pad and first point of thumb.

This prevents instrument slippage and allows greater freedom of movements and cone of movements.

The modified pen grasp and inverted pen grasp are practically used.

Rests: A firm rest is needed to steady the bank during operating procedures.

In modified pen grasp and inverted pen grasp, rests are established by placing the ring or little finger on the tooth or teeth of same arch as close to the operating site as possible.

When palm and thumb grasps are used rests are created by placing the tip of thumb on the teeth being operated upon or on the adjacent tooth or on a convenient area on the same arch.

When rest cannot be established on tooth structure, soft tissues are used but are not reliable.

When it is impossible to establish normal finger rests with the bank holding the instrument control may be gained using a forefinger of the opposite hand on the shank of the instrument or using an indirect rest like resting the operating hand on a non-operating band which in turn rests on a stable oral structure.

Guards: They are hand instruments or other item such as interproximal wedges used to protect soft tissue from contact of sharp cutting or abrasive instruments.

28B Matrices

Matricing is the procedure whereby a temporary wall is created opposite to axial walls, surrounding of tooth structure that were last during preparation.

Matrices are bands of metal or plastic which can act as temporary missing wall and support the restorations during introduction of restorative material in the cavity and during burnishing till the material sets.

Functions of Matrix

1. Helps in establishment of proper anatomical contour to the restoration.
2. Helps in restoring correct proximal contact relation.
3. Aids in preventing gingival excess.
4. Permits adequate condensation of the restorative material in the cavity.

Ideal Requirement of a Matrix Bond

1. Should have adequate rigidity to withstand condensation pressure the material should be unyielding to eneigies and insertion of material.
2. Should be easily contourable.
3. Should not react with restorative materials.
4. Should displace the gingiva and rubber dam away from the cavity margin during introducing the restorative material.
5. Should maintain its shape during hardening of the material.
6. Should cover the circumference of the cavity.
7. Should transmit light in case of light cure material is used.
8. Should not discolor esthetic restorative material.
9. Should confine the restorative material within the cavity preparation and predetermined surface configuration.
10. Should be easily placed and removed.
11. Thickness of the bond should not be more than the elasticity of the periodontal ligament.
12. Should separate the tooth adequately to place the band in the contact area.

Classification of Matrix

1. With retainer and bands with out retainers.

   Bands with retainers example lvory Number 1

   lvory Number 8

   Toefflemine

   Bonds without retainct example

   Automatrix

   Temporary crowns (Polycarbonate crown)

   Seamless copper bond matrix

   Black's Matrix

   Mylar stripe

   Celluloid acetate strips

2. Anatomic and non-anatomic bands
   Anatomic includes custom made crowns:
   Non-anatomic includes, Toefflemaire, Ivory No. 1, Ivory No. 8, Automatrix.
3. Metallic and Non-metallic
   Metallic example Ivory No.
   Ivory No. 8
   Steel Sequeland
   Toeffalemaine
   Automatrix
   Seanless copper bond matrix
   Non-metallic example
   Mylar strips
   Celluloid acetate strips.
   Plastic crown forms
4. Patent and non-patent
   Patented Bands include ivory No. 1 × 8, Toefflemaire etc.
   Non-patented bonds, example: Seanless copper bond matrix
5. Compound supported bonds:
   Bonds supported by impression compound palodent strips.
6. Unilateral bonds: Which replace only one wall: Ivory no.
   Universal bonds: which can replace 2 walls and more
   Ivory No. 8, Toefflemine, steel sequelae
7. Preformed Bonds. Like T Bond, S bond
8. Bonds held with a dental flass: Blacks matrix

Ivory Number 1

This is a unilateral bond which can replace single wall of the prepared cavity. So indicated is unilateral class II cavities.

The band is attached to a retainer by a wedge shaped projection which engages with the tooth at the embrasure of the unprepared surface.

The thickness of the band is 0.0015-0.002 inches. Band can adequately separate the teeth without disturbing the periodontal ligament. The band is ¼- 1/8 inches.

The band should cover 1-2 mm all around the cavity. The band is then attached to the retainer wedge at the both in the band.

The retainer has a screw when on turning clockwise tightens the attached band and on turning anticlockwise widen the band. The beaks of the retainer should reach the bulge areas of the cervical embrasures of unprepared surface.

The gingival end of the band which can be contoured to get the proper fit in the gingival surface with the help of scissor.

Ivory Number 8

They are also called circumferential ivory bands.

This band encircles the entire crown of the tooth so can be used for bilateral class II cavities.

It consist of a thin long metallic band of 0.0015-0.002 inches thickness and ¼th inches width.

When the band is placed in the retainer it forms a loop which can be secured by a first screw. Second screw near the band can be used to adjust the diameter of the loop according to the tooth circumferences.

Another advantage of this band is the use of this band in restoring palatal extensions.

The retainers are to be placed in the buccal aspect of the tooth.

Toefflemaire (Universal Retainer)

It is a universal circumferential band with retainer. It is available as straight and contra-angled types and can be used for all types of cavities.

The contrangled type of retainer can be placed on the lingual surface so adds to operators convenience and also aids in restoring buccal expansion without add of extramatrix band.

The retainer can be separated from the band to expediate removal of the band.

The bands are available in varying occlusogingival measurements which properly contoured accordingly. These have contoured bands 0.002 - 0.0015 inch. precontoured bands are also available and needs little or/adjustment.

To prepare the retainer to receive the band turn the large knurled nuts in the locking vise is short distance from the end of the retainer. Hold the large nut move the smaller nut anticlockwise until the pointed spindle is free of the slot in the locking devices.

When non-contoured bands are to be used, Burnishing the proximal areas with a large egg, shaped burnisher.

Hold the matrix band end to end and form a loop in such a way that the gingival edge is of smaller circumference than the occlusal edge.

Position the band in the retainer so that the slotted side of the retainer is always directed gingivally to permit easy separation of the retainer from the band in an occlusal direction later.

The two ends of the band are placed in the slot of the locking device and the smaller knurled nut is turned clockwise to tighten the pointed spindle against the band.

Slip the matrix band over the both atleast 1 mm apically from the gingival margins but without damaging the attachment of gingival.

Then turn the target not clockwise to tighten the band slightly and tighten the band secure around the tooth.

Slight alteration in the contour and contact is accomplished by back side of the blade of 15-8-14 spoon excavator without removing the band from the tooth.

Automatrix (Roll in Band)

It is a retainer less matrix system with four types of bands which are designed to fit all teeth regardless of circumference.

The bands vary in sight ranging from 3/16-5/10 inch and can be either .0016 inch or 0.002 inch thickness.

This can be used for extensive class II preparations particularly those involve loss of two or more cusps.

As there is no need for retainer no extra space is needed for retainer.

The band is made into a loop and the end is rolled with a latch and then band length in adjusted till there is adequate's fit over the tooth. This also lock loop can be positioned either on the facial and lingual surface with equal case.

The main disadvantage is that this band is available as non-precontoured so development of physiological proximal contours is difficult.

The advantages of this band are convenience. Improved visibility due to absence of retainer.

The loop is tightened with automate II tightening device.

Black Matrix

A metallic band of thickness 0.005-0.002 inches which is little lengthier than the prepared cavity is cut. This should extend slightly over the buccal and lingual surface of the tooth beyond the cavity margins.

The corner of the gingival end is turned up occlusally to hold the ligature (wire or dental floss).

The band is tied around the tooth and secured by tightening the ligature.

The floss can be also held in the band by passing through two holes at the cervical area which is smaller in circumference compared to coronal area.

The floss in held around the tooth and the band is secured in place.

Copper Matrix Band

They are seamless copper band matrix which into available in the form of taken and donot require retainers.

They are used to take impressions of single tooth in the small tube that will fit over the circumference of the tooth and touch all the proximal surfaces, adjacent tooth.

Festoning the gingival end around crown and bridge sussors to correspond to the level of the gingival attachment. Smoothen all rough edges by sand paper disc and contour the cut end with contouring pliers.

Place the band and adjust the gingival end till it is approximately 1 mm from the gingival margins.

Contour the facial, lingual and proximal aspect of the band with a contouring pliers.

Remove the band and cut along the suined line.

Replace the band and insert wedges.

Mylar Strips

They are thin plastic bands used for restoration of anterior teeth especially employing GIC or composites.

These strips are transparent so can facilitate polymerization light core restorative material.

The smooth surface of the strip gives a polished appearance to set material.

These strips do not require retainer and are supported by fingers or wedge planed in the interdental area.

After insertion the free end of the strip as placed over the maternal mechanical holding devices can be also used.

Compound Supported Matrix Band

Sufficient length of stainless steel matrix maternal (8 mm wide and 0.02 inch thick) Material should over the facial and lingual surface slightly beyond the cavity margins of needed thin the gingival end.

Contour the strip to conform to the circumferential contour of the tooth with plies insert the steel strip carefully inserting the gingival edge to the gingival crevice about 1 mm beyond the gingival margin.

Evaluate the band from all directions.

Soften a piece of low fusion compound in flame and shape it into a cone slight glaze the base by passing through the edge and flame quickly. Attain the base to the forefinger. Glaze the tip of the compound and immediately press the softered in the embransure forcing the compound into the embrasure.

Steel Sequeland

They are sleek and thereby takes less space. They are not useful to restore buccal extensions.

Anatomical Matrix/Custom Made Matrix

This is the most effective means of reproducing contact and contour and contoured specifically for each individual cases.

A piece of stainless steel matrix band of 0.001 - 0.002 inch thickness 1/8 inch width is curled using a pair of festooning scissors.

The contour bands is placed on the surface and contoured with plies. It needed trim the gingival edge and is placed and supplied by compound.

S-Shaped Based

A suitable stainless steel band material is selected and is cut at appropriate length. The band in made into gains using the band of a hand instrument.

The band is placed around the prepared tooth with one edge over the sound structure of the involved tooth and the other end around the adjacent tooth.

Contour the band and attain contact.

Support the band with softened compound after wedging.

29A Management of Carious Lesion

INTRODUCTION

Correct diagnosis and treatment of caries is central to clinical dental practice, and accordingly the majority of dental practitioners spend much of time.

1. Deciding whether lesions of caries are present.
2. Accumulating information for each particular patient to make a judgment on how to treated such lesions.
3. Deciding whether to treat the caries or replace restorations.

Unfortunately, this procedure is still empirical, resulting in a great deal of inconsistency.

The aim of this chapter is to discuss the classification of the various types of caries, diagnosis of carious lesion and management of each type of carious lesion.

CLASSIFICATION OF CARIOUS LESIONS

Dental caries has been classified in a number of ways depending upon the

1. Location
2. Extent of caries
3. Rate/speed of caries

Location of Caries

1. Primary caries (original caries)
2. Secondary caries (recurrent caries)

Primary Caries

It is the original carious lesion of the tooth. There are 3 morphological types of primary caries.

a. Enamel pit and fissures
b. Enamel smooth surfaces
c. Root surfaces

Enamel Pit and Fissure Caries

These result in the pit and fissures that result from the imperfect coalescence of the development enamel lobes when the oral conditions conducive to caries are present. These caries form a very small area of penetration in the enamel at the bottom of a pit and fissure and does not spread laterally to a great extent until DEJ is reached.

Pit and fissure caries is presented as two cones, base to base, with the apex of the enamel cone at the point of origin and the apex of the dentin cone directed toward the pulp.

Enamel Smooth Surface Caries (Fig. 29A.1)

This type of caries begins in a smooth area of the enamel surface that is habitually unclear and covered by plaque. Smooth surface caries is also presented as a cone, but its base on the enamel surface and the apex at or directed to the DOJ. Caries again spreads laterally at this junction thus forming a base of the cone presenting the dentinal caries.

Backward Caries (Fig. 29A.2)

When the lateral spread of caries along the DEJ exceeds the caries in the contiguous enamel, caries form DEJ may extend into enamel and is termed backward caries.

Forward Caries (Fig. 29A.3)

Whenever the caries cone in enamel larger or at least the same size as that of dentin.

Residual Caries (Figs 29A.4A and B)

Caries that remains in a completed cavity preparation, may by operator accidentally.

Root Surface Caries (Fig. 29A.5)

It occurs on the tooth root that has been both exposed to the oral environment and habitually concerned with plaque. The root caries is more rapid then other form of caries and hence detected and treated earlier.

Secondary Caries (Fig. 29A.6)

It usually occurs at the borders of the restoration and then under it. This condition usually indicates the microleakage is present with other conditions conducive to caries.

Blacks Classification of Carious Lesions (Figs 29A.7A to F)

Dr GV Black about 100 years ago designed a method to classify the various types of carious lesions:

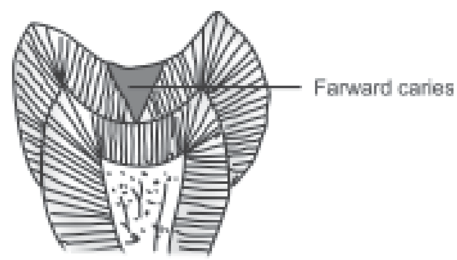


Fig. 29A.3: Forward caries

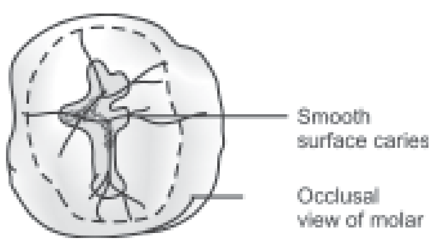


Fig. 29A.1: Enamel smooth surface caries

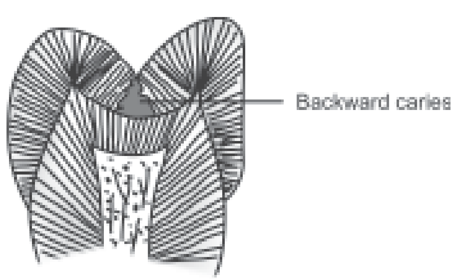
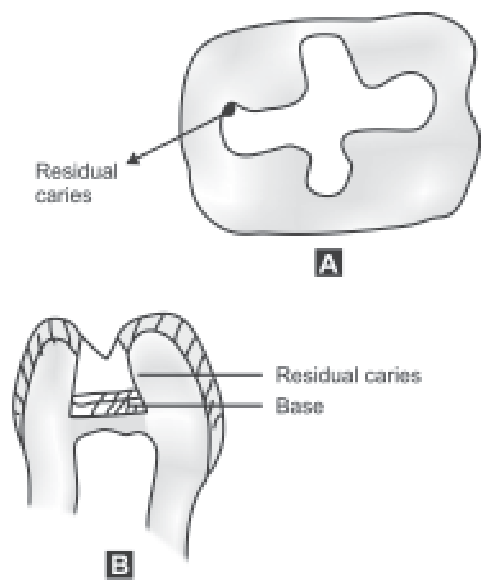


Fig. 29A.2: Backward caries



Figs 29A.4A and B: Residual caries

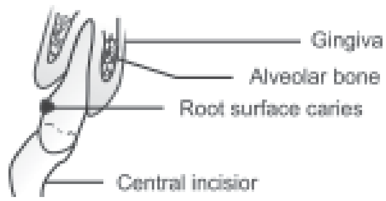


Fig. 29A.5: Root surface caries

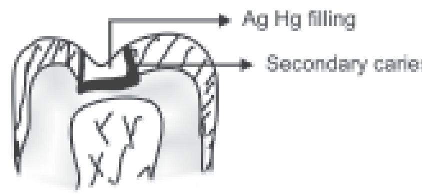
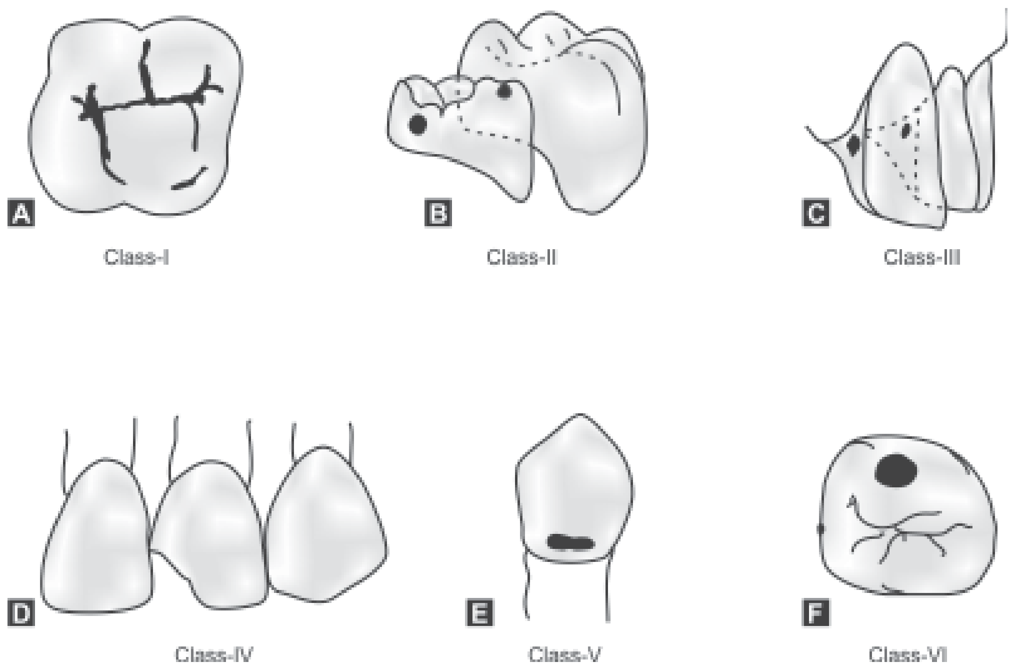


Fig. 29A.6: Secondary caries



Figs 29A.7A to F: Blacks classification of carious lesions

Class I

Class I lesions occur in pits and fissures of all teeth, but this class is essentially intended for bicuspids and molars.

Class II

Class Ii lesion can involve both mesial and distal surfaces or only one proximal surface if a tooth and is referred to as an MO, a DO or an MOD (mesio-occlusal, disto-occlusal, or mesio-occlusal distal) cavity.

Class III

Class III lesion may occur in the mesial or distal surface of any incisor or cuspid. The lesion occurs beneath the contact point, but unlike the molar lesion with its elliptical shape, the class III is small and quite circular.

Class IV

This is actually an outgrowth of a class III lesion. Therefore as defined by Dr. G.V. Black it is a lesion on the proximal surface of an anterior tooth, from which the mesial angle is also missing.

Class V

Class V cavity occurs on either the facial or the gingival surfaces, however, the predominant occurrence of these lesions is adjacent to the lips and cheeks rather than tongue. It can involve cementum as well as enamel.

Class VI

This cavity is found on the tips of cusps or along the biting edges of incisors. In complete union at cusp tips or incisal edges infrequently results in a caries susceptible site.

II. Extent of Caries

Incipient Caries (Reversible)

It is the first evidence of caries activity in the enamel. On smooth surface enamel the lesion will appear opaque white when air dried and will be seen to disappear if wetted. The lesion does not extend to the DEJ and the enamel surface is fairly hard and still intact. These lesions can be remineralized if oral environment conducive to repair is established. Repaired area is opaque white or brown to black from extrinsic coloration, has a hard surface and appears the same whether wet or dry.

Cavitated Caries (Non-reversible)

It has advanced into dentin, the enamel surface is broken (not intact) and remineralization is not possible. Treatment by cavity preparation and restoration is indicated.

III. Rate (speed) of Caries

Acute Dental Caries (Rampant Caries) (Fig. 29A.8)

It is that form of dental caries that runs a rapid clinical course and results in early pulp involvement by the carious process. Occurs most frequently in children and young adults, because the dentinal tubules are large and open, show no sclerosis. The process is usually so rapid that there is little or no deposition of secondary dentin.

Nursing bottle caries is a type of rampant caries seen in deciduous dentition.

The disease presents clinically as widespread carious destruction of deciduous teeth, i.e. most commonly the four maxillary incisors, followed by the first molars and then the cuspids if the habitat is prolonged.

Chronic dental caries is that form which progresses slowly and tends to involve the pulp much later than acute caries. Mostly seen in adults.

The entrance to the lesion is invariable larger than that of acute caries. Due to this there less food retention and a greater access of saliva. Slow progress of the lesion allows sufficient time for both sclerosis of the dentinal tubules and deposition of secondary

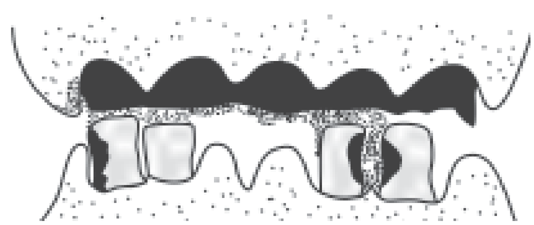


Fig. 29A.8: Rampant caries

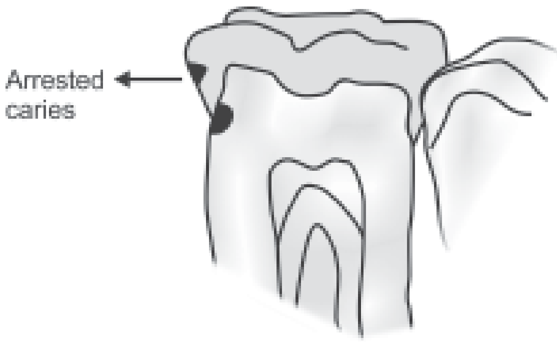


Fig. 29A.9: Arrested caries

dentin in response to the adverse irritation. The carious dentin is often stained deep brown.

Arrested Caries (Fig. 29A.9)

Caries which becomes static or stationary and does not show any tendency for further progression.

Cavities can also be described by the number of surfaces involved.

a. When the lesion is confined to a single surface it is formed a simple cavity, i.e. buccal, lingual or occlusal.
b. When two or more surfaces of a tooth are involved the cavity becomes complex, i.e. MO (mesial occlusal) and MOD (mesial occlusal direct).

Caries Classification Based on Dynamics

(Kilein and Palmer's Classification in 1941)
Class I: Very mild
Class II: Mild (routine lesion)
Class III: Moderate
Class IV: Severe
Class V: V. Severe (Rampant caries)

Diagnosis of a Carious Lesion

Early diagnosis of the carious lesion ahs assumed a particular importance since it is now realized that dental caries can be arrested and reminerailization can take place. Saliva is an excellent remineralizing fluid, particularly if it contains the fluoride ions. Provided the caries is diagnosed in its early stages the balance can be tipped in favour if repair by use of fluoride.

Flow can dental caries be diagnosed in its early stages:

Visual Examination

The diagnosis of caries in the operatory requires good lightening and dry clean teeth. If heavy deposits of calculus or plaue are present the mouth is isolated with cotton rolls to prevent saliva wetting the teeth once they have been dried. Thorough drying should be carried out with a gentle blast of air for there in one syringe. Sharp eyes must be used to look for the earliest signs of disease.

Tactile Examination

Traditionally sharp explorers co-probes have been used to detect the 'tailing' feet of early cavitation. However , this approach has a disadvantage that a sharp probe can actually damage an incipient carious lesion or may carry microorganisms into the lesion, facilitating spread of caries.

Radiographs (Posterior Bitwing Radiographs) (Fig. 29A.10)

Proximal smooth surface caries either 1 degree or 2 degree both can be diagnosed by the posterior bitening radiographs.

The lesions are usually found just cervical to the contact area and may appear as only a break in continuity of the enamel surface.

Radiographic pictures are deceptive as these are 2 dimensional picture of a 3 dimensional object.

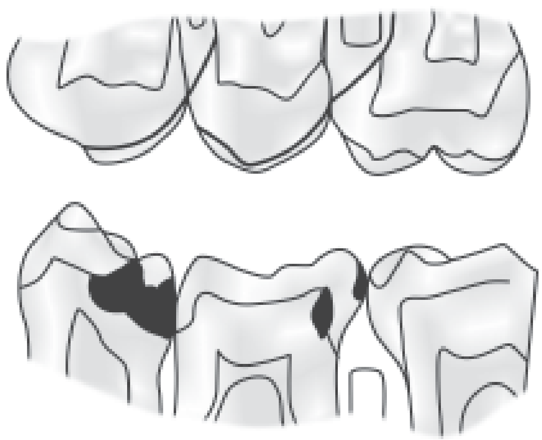


Fig. 29A.10: Bitwing radiograph

Clinical Features of Caries for Diagnosis

a. Caries is mot prevalent in the faulty pits and fissures of this occlusal surfaces where the developmental lobes of the posterior teeth failed to coalesce, partially and completely. Dentist should be able to make a distinction between a primary occlusal grooves or fossa and faulty pits and fissures.

   An occlusal surface is diagnosed as disease if any one of the following clinical/radiographic finding is present.

   1. Chalkiness or softening of the tooth structure forming the fissure/pit.
   2. Brown-gray discoloration radiating peripherally from the fissure/pit.
   3. Radiolucency beneath the occlusal enamel surface.

b. Precarious or carious pits are occasionally seen on the cusps tips which are the result of developmental enamel defects. These can also be seen on the
   – Occlusal 2/3rd of the facial or lingual surface of the posterior teeth.
   – Lingual surface of maxillary meisers.

c. Proximal surface caries is usually diagnosed by radiographs, however, it can also be detected by a careful visual and tactle examination. Careful probing with a sharp explorer on the proximal surface may detect cavitation, but use of all the three examination methods is helpful in arriving at the final diagnosis.

d. Brown spots on intact, hard proximal surface enamel adjacent to end usually gingival to the contact area are often seen in older patients whose caries activity is low.

e. Proximal caries in anterior tooth may be identified by a radiographic examination, usual inspection, translluination or probing with or sharp explorer.

f. Incipient carious lesion on the gingival 3rd area which are less likely to be cleaned may be diagnosed as small white spot lesion that is visually different from the adjacent enamel and will partially or totally disappear from vision by wetting.

g. In case of geriatore patient, extra care must be taken to inspect for root surface caries, i.e. carious lesion that occur on the central surfaces of teeth.

A combination of
- cemental exposure
- dietary changes
- systems diseases
- medications that affect amount of character of saliva.

Can predispose the patient to root surface caries. There are undetectable on the radiographic examination but can be detected with a careful, thorough, clinical examination. Active root caries is defected by the presence of softening and cavitation.

Advances in Caries Diagnosis

Electronic Caries Diagnosis (Caries meter)

It is a device which is used to check the electrical impedence of tooth substance. It measures the electrical resistance of tooth when intact and also when porous due to cantation.

It was reported that when measured with 400 h, the impedence value:

- Of intact teeth between pit and fissures on tooth and oral mucosal is > 600 kilo-ions.
- Of intact teeth between dentin and oral mucosa were 250-600 kilo ohms.
- Teeth with exposed pulp had impedence value between teeth and oral mucosa < 15 kilo ohms.

Transillumination (Proximal Lesion)

Works on the principle that the carious area has lowered index of light and it appears as a dark shadow. A narrow beam of light is produced for transillumination. Any break in the marginal ridge or shadow at marginal ridge extending to DEJ indicates caries.

Caries Detector Dyes

For detection of caries earlier 0.5% basic fusclin was used. Since it proved to be carcinogeniz it has been substituted by 1% acid red in propleve glycol.

Dental Floss

Useful for diagnosis of proximal smooth surface lesions. On passing through the contact area if the floss shreads it indicates a carious rough surface.

Lasers

Nd-YAG (Neodymium Yttrium aluminium garnet) and Coa lasers can be used to diagnose the incipient carious lesions which compare the subsurface zone of demineralization which is more porosity with the surrounding enamels.

Treatment of the Different Types of the Carious Lesions

Enamel Caries or Incipient Carious Lesion

Caries on the free smooth surface which can be diagnosed at the stage of the white spot lesion, i.e. before any cantation occurs. Such lesions are easy to diagnose but not easy to manage as these lesions can be remineralized provided the condition conducive to repair are made available.

These include:

a. Dictary advice
b. fluoride therapy
c. Improved plaque control
   The lesion has to be reassessed in 6 months for repair.

Pit and Fissure Caries

In the initial stage when the pits of fissures are deep but no signs at cantation are present can go for:

– enameloplaty
– proplytactic odontomy
– pit and fissure scollants

When the pits and fissures are present can do enameloplasty, i.e. is grinding away a shallow, enamel developmental fissure/ pit to create a smooth, saucer shaped surface which is self-cleansing or easily cleaned.

Prophylactic Odontotomy

It is minimally cutting open and filling with amalgam developmental, structural imperfections of the enamel, such as pit and fissures, to prevent caries originating in these sites. But it no longer advocated as a preventive measure.

Pit and Fissure Sealants

Either chemically or light activated pit and fissure sealants can be used to seal the fault areas on the occlusal surface after acid etch technique so that no plaque and bacteria get accumulated in these areas.

Glass ionomer cements can also be used as sealants.

Recent Advances

CO_2 lasers can be used to fare the faulty pits and fissures by photoablation. So that they are rendered easily cleansable.

Now coming to the different depths of the cavity seen on the occlusal surface.

A. When the cavity is within 0.5 mm inside DEJ, i.e. a shallow amalgam cavity preparation. Varnish is applied to walls of preparation before insertion of restoration.

B. For a moderate depth cavity, i.e. remaining dentin thickness is > 1.5 mm.
   The basic idea here is the pulp protection requiring considerations.
   a. chemical protection
   b. electrical protection
   c. ohermal protection
   d. pulpal medication
   e. mechanical protection
   Patient may exhibit sensitivity to cold stimuli.
   We apply a thick liner of 0.2 to 1 mm thickness or a base of Zno Eugenol is $Ca(OH)_2$ followed by varnish and restoration.

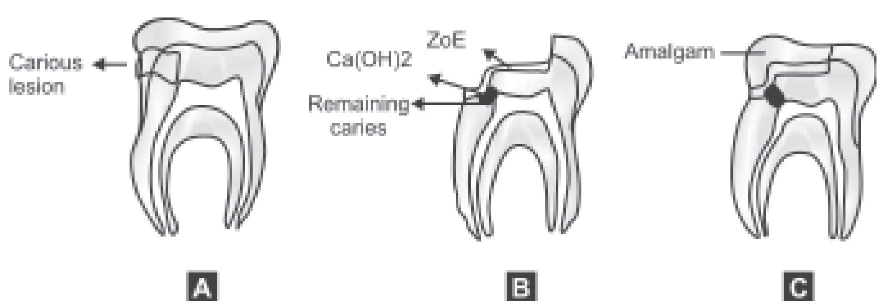
C. When the dentin thickness is 0.5 to 1.5 mm thick. In this we use light cured $Ca(OH)_2$ in the deepest region in which infected dentin was excavated and then base of glass ionomer is inserted, varnish is applied. Followed by restoration. Amalgam bonding systems are being advocated as a substitute for liner and varnish, except in very deep cavity where $Ca(OH)_2$ has to be used.

D. Where the thickness of remaining dentin is $\leq$ 0.5 mm. $Ca(OH)_2$ followed by GIC or polycarboxylate cement base. We never use zinc phosphate cement because the free phosphom acid will neutfralize the effect of $Ca(OH)_2$.

Indirect Pulp Capping (Figs 29A.11A to C)

We perform this procedure only if the
a. The tooth reacts positively to Co_2 test.
b. Radiograph in hand.

Radiograph gives us an approximation of the expanse of the carious process more precisely the demineralization of dentin towards the pulp.



Figs 29A.11A to C: Indirect pulp capping

What do we expect from the indirect pulp capping?

- Neutralization, drying out and hardening at the soft infected and acidic remains of dentin, with a simultaneous reduction in the number of caries microflora.
- Consolidation of the condition of the pulp, in the sense of diminution of inflammatory characteristics of normalization of acceleration.
- Stimulation of odontoblasts, in so far as any remains, and of fibroblasts and undifferentiated messenchymal cells towards osteogenic and dentinogenic activity.
- Maintenance of pulpal vitality, even if the acute pathological processes have severely altered the pulpal tissue.

Materials Used for Indirect Pulp Capping

a. Zinc oxide eugenol cements
b. Calcium hydroxide preparations

Procedure for Indirect Pulp Capping

a. Before beginning the procedure perform a CO_2 vitality test and take a radiograph.
b. Administer anesthesia and completely prepare the cavity with regards to extension of retention form.
c. Dry the field (rubber dam).
d. Carefully excavate affected dentin near the pulp if leaving carious dentin would surely expose the pulp, leave only a very tiny area.
e. Spray out and dry the cavity, check for hardness with an explorer.
f. Indirect pulp capping with ZnO-eugenol or $Ca(OH)_2$ preparation.
g. Place a cement base (if necessary) and definitively restore the cavity, take a radiograph.

Direct Pulp Capping (Fig. 29A.12A)

It signifies the treatment of an iatrogenically or otherwise exposed pulp with an indicated dressing. The goal is maintenance of pulp vitality.

Pulp exposure may occur accidently.

- during caries excavation of deep cavity
- of tooth due to trauma

Pulp Capping Materials are:

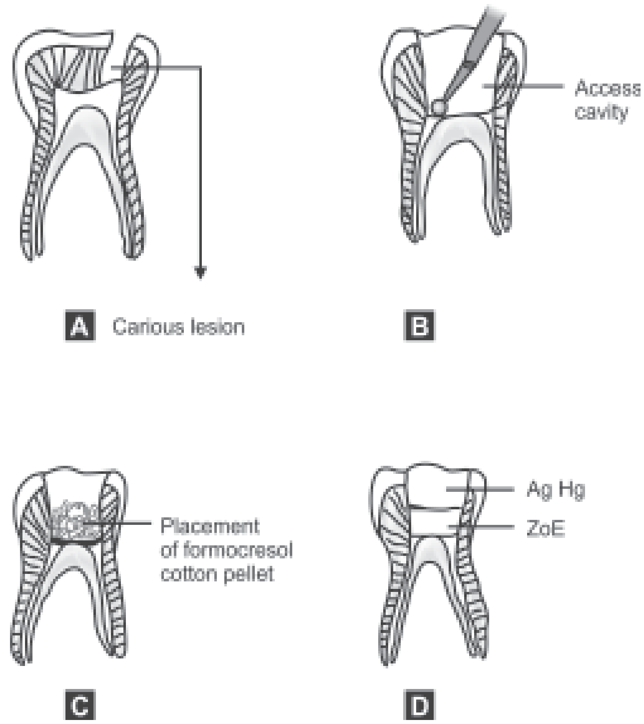
1. Zuo eugenol
2. Calcium hydroxide $(Ca(OH)_2$
3. Biological substances. Dentins or ivory aligns, carplaque bone, collageal mucopolysalllemits etc)
4. Tissue adhesives

Most commonly used material is $Ca(OH)_2$.

In 1920 Thermann recommended the compound $Ca(OH)_2$ for pulp treatment and root canal filling. In his original formula. (Calxyl) it is a watery paste with value of 12.3 to 12.5 consisting of $Ca(OH)_2$ and Ryer's solution.

Direct pulp capping can only be done if following are present.

A. There are no signs and symptoms of degenerative on the PD organ and there is significant evidence of reasonable reparative capacity.
B. The exposure has the following characteristics:
   1. The exposure is pinpoint and not more than 0.5 mm inside.
   2. No observable hemorrhage on the access site.
   3. The dentin at the periphery is repairable as verified by different visual and tactile tests.
   4. The exposure is not at a completely or partially constrained area in the pulp chamber of root canal system.
C. The field of operation B completely aseptic.



Figs 29A.12A to D: Direct pulp capping

Procedure

- After exposure place a sterilized cotton pellet saturated with 30% H_2O_2 over the exposure site.
- By the area so apply the rubber dam if this has not already been done.
- Remove completely all remaining carious dentin.
- Repeatedly clean the cavity and the exposure site with 3% H_2O_2 this will also serve to stop any bleeding.
- Close the site with an application of a well sealing cement which can simultaneously act as a cement base filling (200 Egonel cement, e.g. EBA).
- Definitely restore the cavity at the same appointment.
- Radiograph.
- Later check tooth vitality regularly.

29B Management of Deep Carious Lesion

Deep carious lesions are the one in which the caries is closer to the pulp or almost reached the pulp. Any lesion extending more than 2 mm from the DEJ can be considered as deep carious and require special management.

The mode of treatment of such lesion depends on the extend of lesion, size of the lesion and the progress of lesion.

DIAGNOSIS OF DEEP CARIOUS LESION

No particular diagnostic method gives an exact picture of the involved tissue, like the extent of degenerating changes in pulp or the reparative capacity of the remaining tissue. A diagnosis is arrived at combining the results of various clinical tests and from observation. It is not good to rely completely on one method.

Various clinical tests used for evaluating the pulp condition and the extent of caries are:

Pains

Pain is often the chief complaint of patients with deep caries. The degree of pain depends on the extent of the lesion and the extent of pulpal changes. It can also vary from one person to another. Pain at night or spontaneous pain are often suggestive of degenerative changes in the pulp dentin origin. Whereas pain on thermal or chemical stimulation which disappears immediately or removal of the stimuli indicates lesser degree of degenerative changes.

Pulp Testing

This can be either thermal pup testing or electrical pulp testing.

Thermal Pulp Testing

This is accomplished by simple application of heat or cold on the tooth. Heat stimuli is usually applied by heated compound of gutta-percha sticks. In tooth with full coverage from a rubber cup can be applied to the tooth under pressure to produce frictional heat, cold stimuli is applied with a aid of cotton pellet soaked in ethylene chloride or liquid nitrogen or simply by sticks of ice.

A positive response to any of these thermal stimuli suggest that there is some degree of pulp vitality. But a negative response is not confirmative of non-vital pulp because the thermal conductivity of enamel and dentin is low. So if these structures are of much bulk. There will be failure of transmission of these stimuli to the pulp.

Electric Pulp Testing

This is accomplished by device that generate electric current. When the electrode conducting this current is placed on the tooth the stimuli is carried to the pulp. If a positive response is elicitated by this; Compare the response with adjacent, opposing and contralateral teeth. If the minimum energy required to elicit a response in the tooth is lower for the control teeth, there are chances of acute changes in the pulp of the affected teeth. If the energy required if higher than in the adjacent tooth, progressive chronic changes, advance repair of the pulp is taking place.

False positive can also occur in recently devitalized tooth because the inflammatory exudates and pus that fill the pulp chamber or root canal is a good conductor of electricity. Similarly false negative can occur in dehydrated or demineralized teeth due to its poor electrical conductivity.

Therefore, electric pulp testing should not be the sole diagnostic tool to calculate the vitality of the tooth.

Direct Pulp Exposure

If the exposure is pinpoint and surrounded in the periphery by sound dentin. Usually there will be not any hemorrhage. This indicates that there is no pulpal inflammation or only mild degree of it.

If there is drop of blood at the exposure which coagulate immediately also indicates healthy reparable pulp.

But if the exposure is large and is surrounded by infected dentin on its periphery it indicates pulpal inflammation. This is usually associated with bleeding which is not controlled easily.

Percussion Sensitivity

Usually teeth with extensive pulpal in inflammation are tender on percussion. This is not fully reliable as the pain reaction can vary from person to person, therefore, it only suggests a likelihood of some pathology of pulp.

Visual Examination and Tactile Evaluation

Dentin which appear grayish brown or grayish pink all throughout the lesion may indicate a devitalized or devitalizing pulp. This usually occurs when the dentin has lost its reparative capacity.

Tactile evaluation using an exploser usually will give us an idea of type of dentin present in the lesion. If the base of the lesion is soft it means that caries lesion has extended towards the pulp. Similarly if the dentin is hard but discolored it indicates formed reparative dentin.

Removal of Tooth Structure without Anesthesia

Dentin removal close to the pulp either using a spoon excavator or rotary instrument is a reliable test to pulp vitality. If there is pain on such procedure the pulp is vital whereas there will be no pain if the pulp is devitalized.

Selective Infiltration or Ligamental Anesthesia

This is useful, when the patient complains of pain in one side of the arch. In such cases local in filtration anesthesia for the most suspected tooth should stop the pain if that tooth is the offending one.

Use of Certain Dyes to Differentiate Reparable Dentin from Irreparable Dentin

0.5% basic fuschin.

Radiographic Diagnosis of Deep Caries Lesion

- A properly taken radiograph (IOPA) can show.

- The proximity of the caries lesion to the pulp chamber or root canal system.
- The approximate thickness of dentin between the lesion and the pulp can be estimated.
- Any pulpal changes in the form of intrapulpal or peripulpal calcification which denotes the decreased reparability of pulp.
- Any thickening of periodontal ligament space with intact lamina dura indicates increased vascularity and thereby increased activity of the pulp. Discontinuity of lamina dura most probably indicates destructive activity of the pulp
- The location of the caries cone tip relative to anatomy of pulp chamber.

Treatment of Deep Caries

For Acute Decay

Remove all undermined enamel in the preparation and remove all softened dentin without creating exposure using a spoon excavator.

If there is danger of pulp exposure on such excavation leave the deep layer but in such cases the pulp should be evaluated to be healthy so that reparative dentin will form.

For Chronic Decay

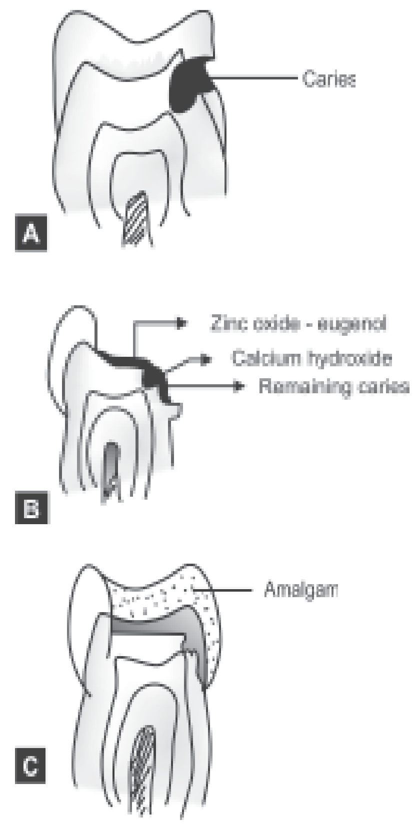
Remove all softened dentin using spoon excavator or round stainless steel bur in slow speed handpiece.

If such removal leads to exposure of pulp proceed either with pulp capping procedure or go in for endodontic therapy.

Indirect Pulp Capping (Figs 29B.1A to C)

This is indicated when complete carious removal may lead to pulp exposure.

Rationale: For caries progression three items are needed, i.e. tooth structure, micro-organisms and substrate. So when one of this factors is removed the caries process will stop. In this procedure we remove two items



Figs 29B.1A to C: Procedure of indirect pulp capping

namely microorganism and substrate so there is no caries progression.

In chronic decay some microorganisms that remain after excavation will be rendered inert by effectively sealing them off from their substrate source. This is accomplished by temporary restorative material. Thus, a favorable environment is created for repair of the damaged tooth structure. Thus, there will be remineralization of decalcified dentin at the cavity floor and there will be deposition of secondary or tertiary dentin pulpal to the carious lesion.

This procedure should be only performed on teeth that do not any pulpal degeneration till that time.

Technique

Excavate all decayed and infected zones and external parts of decalcified zone in the carious lesion using a spoon excavator. Thus, tooth structure in the surrounding walls is cleared.

Depending on the depth of the excavation and the reparability of pulp, a suitable capping material is placed over the remaining softened dentin on the pulpal floor and/or axial walls. Calcium hydroxice is preferred for area. Zinc oxide eugenol can be also used.

Temporarily restore the cavity with either modified zinc oxide eugenol, zinc ploycarboxylate or other temporary restorative material. The tooth should be in occlusal function following this restoration because functional use is believed to accelerate repair process of pulp.

Recall the patient after 4-6 weeks, if the capping material is calcium Hydroxide or 6-8 weeks if zinc oxide engenol is used.

On the second visit take a radiograph and compare it with earlier one. If there is no evidence of degenerative changes, the procedure can be considered a clinical success.

Now all undesirable and/or undermined enamel is removed and prepare the tooth for permanent restoration. The capping material and a part of the temporary restoration is life in place to act as base. Some prefer to remove these material and remove the left softened dentin. Place the permanent restorative material.

If repair is not apparent and there are signs of degeneration of the pulp, endodontic therapy is instituted immediately.

If such excavation of softened remaining dentin under the capping material leads to pulp exposure proceed with direct pulp capping or endodontic therapy.

Direct Pulp Capping (Figs 29B.2A to D)

This is indicated, when pulp exposure occurs either during carious removal due to deep carious or pinpoint exposure mechanically during cavity preparation.

There should not be any degenerative changes in the pulp.

The exposure in such cases should have the following characteristics.

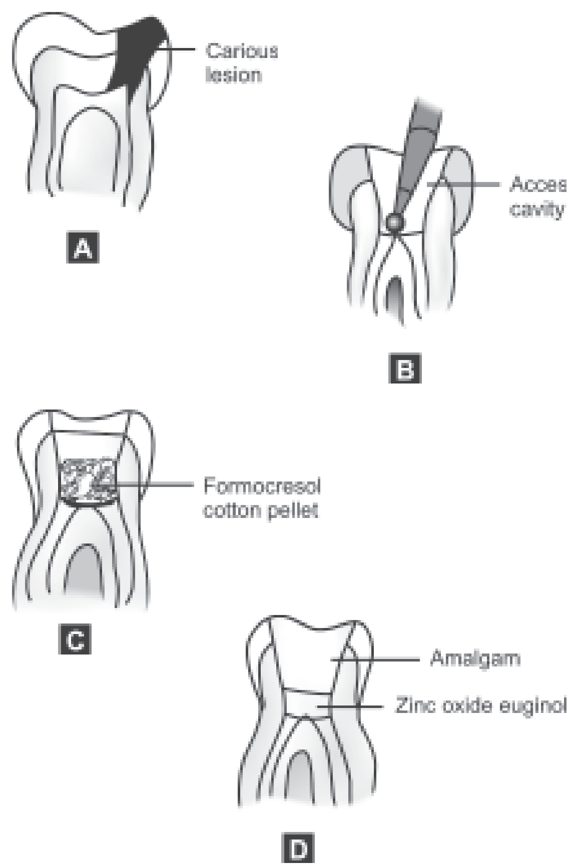


Fig. 29B.2A to D: Procedure of direct pulp capping

1. Pinpoint exposure.
2. No observable hemorrhage from the exposure site or if there is hemorrhage it should be controllable.
3. The exposes site is completely aseptic.

Rationale

The basic idea is to create a dentin bridge (composed of secondary or tertiary dentin) at the exposure site. This can be brought about by certain medicaments like Calcium Hydroxide or Zinc Oxide eugenol placed over the site.

Procedure

Exposer site and the cavity floor is gently washed and irrigated with sterile water. Dry the area with sterile cotton pellets.

Place the capping material (calcium hydroxide or modified zinc oxide eugenol) at the area of exposure. When zinc oxide eugenol is the capping material, place dentinal chips at the exposure site which are obtained from surrounding walls. If calcium hydroxide is used, use it directly.

Then place the permanent restoration. But if cast restorations are to be used temporarily, cement the restoration till the pulp status is well established.

Recall after 6-8 weeks if $Ca(OH)^2$ is the capping material or 8-9 weeks if ZnO is the material. Evaluate the pulpal states and observe for any calcific bridge on the radiograph.

If pulp shows degenerative changes, go for endodontic therapy.

30 Speed in Dentistry

INTRODUCTION

The workman is known by his tool, before beginning the performance of various operative procedure with which one will become familiar, it is first necessary that one possesses some knowledge of his armamentarium. In order to perform the intricate and detailed procedures associated with operative dentistry, the dentist must have a complete knowledge of the purpose, availability and application of the many cutting instrument required.

Skillful application of hand and rotary cutting instruments requires psychomotor skill attained only by intensive training.

DEFINITION

Speed

Speed is the distance an object moves during a unit of time. Common units of speed are meters/second and miles/hour and is expressed in revolutions/minute (rpm).

Speed refers only to the rate of motion without specifying any direction of motion. It therefore differs from velocity in a technical sense because velocity is a vector quantity and specifies a direction (Lexicun Encyclopedia).

Speed is the magnitude of velocity without regard to directions (Stedman's dictionary). Speed as the rate of change of position with time (According to Mosby's Medical Dictionary).

Handpiece

Handpiece is a device for holding the rotating instruments, transmitting power to them and for positioning them intraorally.

HISTORICAL BACKGROUND

Prior to 1870, Dentists had no driven rotary tools for caries removal and cavity preparation. The procedure of cleaning away overhanging enamel was undertaken by hand instruments, called "enamel cutters" which enabled carious dentin to be then scooped out with excavators.

Development of Rotary Cutting Equipment

The development of rotary cutting equipment begins in 1952 with the ultrasonics (non-rotary instrument) to the present day air turbine handpieces.

1952 Ultrasonics –Non-rotary

1953 Ball bearing handpicecs – 25,000 rpm

1955 Water driven turbine handpieces – 50,000 rpm

1955 Belt driven angle handpiece –1,80,000 rpm

1957 Air driven turbine angle 2,50,000 rpm handpiece with ball bearings (2 ½ lakhs)

1961 AIIIIIjir driven turbine straight handpiece – 25,000 rpm

1962 Air driven turbine angle handpiece with air bearings – 8,00,000 rpm (8 lakhs)

1994 Contemporary air – turbine handpiece - 3,00,000 rpm (3 lakhs).

CLASSIFICATION

I. According to Sturdevant:
   1. Lower slow speeds – Below 12,000 rpm
   2. Medium or intermediate speeds - 12,000 RPM to 2 lakhs rpm
   3. High or ultrahigh speeds – Above 2 lakh rpm

II. According to Marzouck:
   1. Ultra low speed –300 to 3 ,000 rpm
   2. Low speed - 3000 to 6000 rpm
   3. Medium high speed –20,000 to 45,000 rpm
   4. High speed 45,000 to 1,00,000 rpm
   5. Ultra speed-1,00,000 rpm and above

III. According to Charbeanu ;
   1. conventional or low speed below 10,000 rpm
   2. increased or high speed –10,000 to 1,50,000rpm
   3. ultra speed- above 1,50,00 rpm

IV. According to clearance L. Sockwell (DCNA – 1971) vol.4
   1. low or conventional speed – below 6,000 rpm
   2. high or intermediate speeds – 6,000 to 1,00,000 rpm
   3. Ultra or super speed – above 1,00,000 rpm
   4. Variable Speed/Optimum Speed: complete range of speeds should be available for efficient operation. The use of a variable control to regulate the speed makes the handpiece more versatile. This allows the operator to obtain easily the optimum speed for the size and type of rotary outing instruments at any stage of a specific operation. (Ref. from Dental clinics of North America, January 1971. Vol 50, Pg. 226)

Types of Speed are as follows:
1. Free running speed: When the rotary cutting instrument is not in contact with the tooth tissue.
2. Cutting speed or operational speed : When the rotary cutting instrument is in contact with tooth tissue. This is less than free running speed.

Coast Speed

Even after leaving the foot control, bur still rotates because of air left in the tubing. It is amneable to cause soft tissue injury due to the negligence of the operator. This is only when using the high speeds, i.e. a turbine handpiece.

Low Speed

While the low speed range no longer is used for cavity preparation, it seems logical that there always be a need for speeds below 600 rpm for such operations as:
- Excavating deep caries with round burs.
- Refining cavity preparations
- Using sand paper discs
- Marginating gold restorations and
- Polishing procedures

Disadvantages of Low Speed

1. Removal of tooth structure at low speed is a traumatic experience for both the patient and the dentist.
2. Ineffective, time consuming and requires a force of application (force required is 2 to 4 pounds). This results in excessive

heat formation at the cutting site and produces annoying vibrations of low frequency and high amplitude.
3. At low speed, burs have a tendency to roll out of the cavity preparation and over the proximal cavo surface angles.
4. At low speeds, the rotary cutting instruments do not last long because brittle carbide blades are broken from burs and particles are dislodged from diamond instruments (because of the force of application and other factors).

History of High Speed

Recognition of the benefits of high speed.

The Belgian dentist Emil Huer (1874-1944) is thought to have been the first to recognize the benefits of higher rotary instrument speeds.

In 1911, he developed an electric engine which repeatedly achieved rotation rates of upto 10000 rpm (167/s).

(This reference is from an article of Australian Dental Journal 1993. Vol. 38: Pg. 53).

High Speeds

The high speed range can be used for cavity preparation although not as effectively as ultraspeeds.

If the high speed is used a large selection of specifically shaped burs, and diamond instruments is as the placement, of retentive grooves and bevels are best performed at high speeds.

Advantages of High Speed

1. Increased cutting efficiency.
2. Faster, hence less pressure, less vibration and less heat generation.
3. The number of rotary instruments reduced because, smaller sizes are more universal in application.
4. Operator has better control and less fatigue.
5. Rotary cutting instruments last longer.
6. Greater ease of operation
7. Patients less apprehensive because less annoying vibrations, less noise and operation time is reduced.
8. Less time, reduced tension and fatigue for both the operator (dentist) and the patient.
9. In overall, it is possible to perform better dentistry with less time with managing more patients.

Disadvantages of High Speed

1. Desiccation of dentinal tubules:
   Use – Air spray frequently removes the smear layer.
2. Impaired visibility due to water spray.
3. Mechanical injury to soft tissue due to coast speed.
   This can be avoided by:
   – Use of rubber dams
   – Latest H.P. has exhaust for air
   – Take care while removal of handpiece
4. Over cutting of tooth: This can be avoided with experience.
5. Eye damage: Due to the flying tooth/ restorative material particles. This can be avoided by protective eye wear for both the dentist and patient.
6. Noise: High pitched where from air turbine can cause hearing damage.

Ultraspeed

At speeds above 1 lakh rpm, smaller, more versatile cutting instruments are used. This speed range is desirable for such operations as:
1. Bulk reduction
2. Obtaining outline form and
3. Removing metallic restorations

Some cavity preparations may be completed entirely at ultraspeeds but usually the operator will use lower seeds for finishing touches.

Rotary Cutting Equipment

Development

The development of rotary equipment was an evolutionary process. Although there is an archeological evidence of dental treatment as early as 5000 B.C. Little is known about the equipments and methods used then. Early drills were powered by hand and subsequent history lead to the present powered cutting equipment. This powered cutting equipment can be seen as a search for improved sources of energy and means for holding and controlling the instrument. This has culminated in the use of replaceable bladed or abrasive instruments held in a rotary handpiece usually powered by compressed air.

The development of rotary equipment was an evolutionary process up until 1946. The most significant dates, instruments and approximate maximum speeds are listed as follows (rpm):

Year	*Instrument*	*Speed*
1728	Hand driven rotary instruments	300 rpm
1871	Foot driven engine	700 rpm
1874	Electric engine	1000 rpm
1914	Dental unit	4000 rpm
1942	Diamond cutting instruments	5000 rpm
1946	Old units converted to increase speed	10000 rpm
1947	Tungsten carbide burs	12000 rpm
1951	Air brasives	Non-rotatry

DEVELOPMENT OF DENTAL HANDPIECES

The dental high speed air turbine handpiece having rapidly gained widespread acceptance from the dental profession from its introduction more than 3 decades ago, continues to be used as the main means of carrying out cutting work in most dental practice.

The history of development of handpiece followed by some general principles which includes:
1. Compressed air turbine
2. Gas turbine
3. Smoke jack
4. Green's pneumatic engine
5. Straub's turbine
6. Iceman's turbine
7. Norlen's turbine

Note: The first handpiece with turbine was invented by Francis R. Callaghan in 1952 (New Zealand).

Year	*Developments*
1728	Hand rotated instruments – 300 rpm Drills or bur heads were used Searnton's drill
1871	Morrison adopted dental foot engine – 700 rpm
1910	Belt driven handpiece – 3000 rpm
1947	Tungsten carbide burs – 12000 rpm
1953	Ball bearing handpiece – 25000 rpm
1955	Nelson – water turbine contrangle handpiece – 50000 rpm
1957	Air turbine contrangle handpiece – 300000 rpm
1962	Air bearing contrangle handpiece – 5 lakh to 8 lakh rpm

Hand Drills

Types of hand drills are:
1. Straight hand drill
2. Angled hand drill

Straight Hand Drills

Used direct access cavities which was available in the trade name of CIRCA with a code 1800 or else we call it as CIRCA-1800.

Angled hand drills were used for indirect access cavities which was also available in the trade name of CIRCA – 1850 (The bur is activated by squeezing spring loaded handle).

CLASSIFICATION OF HANDPIECES

I. *Based on the design:*
   1. Straight handpiece
   2. Contrangle handpiece
   3. Prophylaxis angle handpiece

II. *Based on power mechanism:*
   1. Straight
   2. Belt driven
   3. Gear driven
   4. Water driven
   5. Air driven
   6. Direct motor driven
   7. Air motor

III. *Based on speed as:*
   1. Straigh
   1. Ultra low speed – 300 to 3000 rpm
   2. Low speed – 3000 to 6000 rpm (These speeds are used in cleaning, excavating, polishing and finishing cavity preparations).
   3. Medium high speed handpieces: 20000 to 45000 rpm used for finishing procedures, placement of retentive grooves and bevels.
   4. High speed handpieces: 45000 to 100000 rpm.
   5. Ultra high speed handpieces : 100000 to 500000 rpm. 1 lakh to 5 lakhs rpm.

      This high speed and ultra high speed are handpieces used in grooves cavity preparation and reduction of cusps.

IV. *Handpieces used in endodontic procedures :* Endosonic handpieces, e.g. Gioromatic handpieces.

   These have speed of 1500 to 6500 rpm.

Belt Driven Handpieces

It is also called as Page-Chayes.

- Became available in 1955.
- It was the first angle handpiece to operate successfully at speeds above 1 lakh rpm.
- Belt drive angle handpieces are relatively free of maintenance problems because the bearings have factory sealed lubrication.
- They have a history of excellent performance and great versatility.
- Improved models of the belt driven design are the:
  1. Page chayes 909
  2. Twin 909.

Gear Driven Handpieces

- One of the oldest and largest group of handpieces.
- Generally, it is also known as conventional type of handpiece.
- Based on the design and use.

Three types are there:

1. Straight handpiece
2. Contrangle handpiece
3. Prophylaxis angle
   - Conventional handpieces are designed to operate at speeds under 5000 rpm.
   - Gear driven handpieces are very versatile being capable of a wide speed range and use.
   - All operative procedures can be accomplished with this type of equipment.

Water Driven Handpiece

In 1953, a hydraulic driven turbine handpiece was reported to operate satisfactory at 60,000 rpm.

- Two years later, the first commercial model called "Turbo Jet" became available.
- Improved units have both straight and angle handpieces which will operate at speeds upto 1 lakh rpm.

- Electricity is needed to operate the unit.
- The sound proof cabinet contains a motor, water pump, water reservoir and the necessary plumbing for circulating water.

Air Driven Handpieces

In 1956, the first clinically successful air-driven turbine handpiece become available with free-running speeds of approximately 3 lakh rpm.

A small compact unit consists of a handpieces, control box foot control and various connector horses.

Air driven turbine handpieces have been and continued to be the most popular type of handpiece equipment, due to overall;

1. Simplicity of design
2. Ease of control
3. Versality and
4. Patient acceptance

Reciprocating Handpiece

It is a handpiece that changes the rotating movement to a reciprocating of an alternating quarter turn movement.

E.g. The Giromatic – used in endodontic therapy.

Note : This can turn in both directions.

Miniature Handpieces

These are the handpieces that are used to hold the small burs and can be used in operations relating to the most posterior teeth where the regular handpieces cannot be worked with.

DENTAL BURS (FIG. 30.1)

"The term bur is applied to all rotary cutting instruments that have bladed cutting heads". This includes instruments intended for such purposes as finishing metal restorations and surgical removal of bone as well as those, primarily intended for tooth preparation.

Historical Development of Dental Burs

The earliest burs were hand made. Thus, they were both expensive and variable in dimension and performance.

The shapes, dimensions, and nomenclature, of modern burs are directly related to those of the first machine made burs introduced in 1891.

Early burs were made of steel. Steel burs performed well cutting human dentin at low speed but dull rapidly at higher speeds or when cutting.

- Once dulled, the reduced cutting effectiveness creates increased speed and vibration.
- In 1947, carbide burs were introduced.
- Carbide burs performed better than steel burs at all speeds and their superiority is greater at high speeds.
- All carbide burs have heads of cemented carbide in which microscopic carbide particles usually of "tungsten carbide" are held together in a matrix of cobalt or nickel. Carbide is much harder than steel

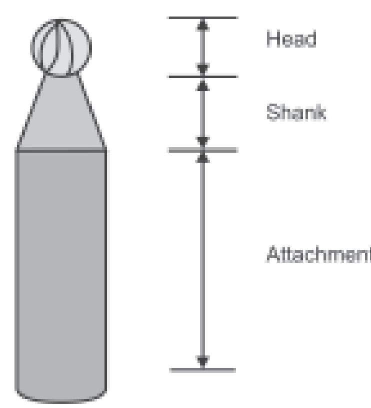


Fig. 30.1: Dental bur and its part

and thus less subject to dulling during cutting.

Classification of Dental Burs

I. Depending upon composition:
   1. Steel burs or the material used for their manufacturer.
   2. Tungsten – Carbide burs.
   3. Diamond points.

II. Depending upon head shape of the Bur:
   1. Round
   2. Inverted cone
   3. Pear shaped
   4. Tapered fissure
   5. Straight fissure

III. According to William H.O. McGehee:
   Head shape Numbers
   1. Round (excavating burs) – 1/2, 1,2,3,4,5,6,8,9,10,11
   2. Inverted cone – 33 ½ , 34,35,———— to 44
   3. Wheel – 11 ½ ,12,14,16
   4. Fissure flattened – 56, 57, 58, 59, 60
   5. End cutting – 957,958,959,960,961
   6. Round (Dentate burs) – 502,503,—— ——507
   7. Fissure flattened – 556,557,———— ——562
   8. Fissure pointed – 568,569,570

Tapered Fissure:
1. Plane – 600,601,602
2. Fine cut dentate – 603,604,605
3. Coarse cut – 700,701,702,703

IV. Recent Classification (1955 to Present)
   1. Round
   2. Wheel
   3. Inverted cone
   4. Plane fissure
   5. Round cross cut
   6. Straight fissure cross cut
   7. Tapered fissure cross cut
   8. End cutting fissure
   9. Round finishing
   10. Oval finishing
   11. Pear finishing
   12. Flame finishing

Round Bur

- The head of round bur is spherical in shape.
- The shape customarily has been used for purposes has;
  1. Initial entry into the tooth
  2. Extension of the preparation
  3. Preparation of the retention patholes
  4. Caries removal

Inverted Cone Bur

It is a portion of the rather rapidly tapered cone with the apex of the cone directed towards the bur shank.

- Head length is about the same as the diameter of the bur.
- This shape is particularly suitable for providing undercuts in cavity preparations, cavity extensions, for establishing wall angulations and retention forms.

Pear-shaped Bur

- Is a portion of a slightly tapered cone with the small end of the cone directed toward the burshank.
- The end of the head is either continuously curved or flat with rounded corners where the sides and the flat end intersect.
- A normal length pear bur, (length slightly greater than the width) is advocated for use in class I cavity preparation for goldfoil.
- A long length pear bur length 3 times the width is advocated for cavity preparations for amalgam.
- Mainly used in pedodontics.

Straight Fissure Burs

- Is an elongated cylinder.
- This shape is advocated for some amalgam cavity preparations.
- Modified burs with slightly curved tip angles are available.

Used for

1. Cross cutting
2. Cavity extensions and
3. Creation of walls

Tapered Fissure Burs

- Is a portion of a slightly tapered cone with the small end of the cone directed away from the bur shank.
- This shape is used for inlay and crown preparations where freedom from undercuts is essential for successful withdrawal of patterns and final seating of cast restorations.

Size of the Burs

In the United States, the number designating the bur size also has traditionally served as a code for head design. The numbering system for burs was originated by the S.S. White Dental Manufacturing Company in 1891, for their first machine made burs.

It was both extensive and logical, so that other manufacturers, found it convenient to adopt if for their burs, as well.

The original numbering system grouped burs by (1) shapes and (2) sizes. The ½ and ¼ designations were added later when smaller instruments were included in the system.

Common Designs of Shank of Burs

1. Straight handpiece shank
2. Latch type handpiece shank
3. Friction grip handpiece shank

Rotary Diamond Instruments

(From the Status report on rotary dental instruments) taken from JADA, Vol. 97: August 1978 pp. 233-235.

Rotary diamond instrument for use in dentistry was developed about 30 years ago.

The two most important factors, in the development, specifications and use of diamond dental instruments are their;

- Cutting efficiency
- Durability

Availability

All of the available rotary diamond instruments are made by electroplating diamond grit on the blank with use of nickel, nickel and chromium and chromium bonding material.

Some manufacturers claim to use only natural diamond grit whereas others use synthetic as well as natural diamond particles.

Considerations for use of Rotary Diamond Instruments

Diamond rotary cutting instruments should be selected by the dentist on the basis of the operation to be accomplished.

Coarse Grit Diamond Instruments

Are intended to be used for bulk reduction of tooth structure.

Regular or Medium Grit Instruments

Are designed for routine operations on enamel, dentin and amalgam.

First Grit Instruments

Use in finishing walls and margins of the preparations.

Extra Fine, Very Fine or Superfine Grit

Are most frequently used during the finishing of composite resin restorations.

For Optimum Efficiency

A water spray of sufficient volume which can be evacuated adequately should be used with the rotary diamond instrument.

Criteria for Consideration

The following are the factors important in the manufacture and use of rotary diamond instruments.

- For safety, the instrument should be concentric
- For safety, the instrument shaft should be strong enough to resist breakage with normal usage.
- For enough, the instrument blank and must be resistant to corrosion with normal usage.

For Accuracy or Efficiency

- The particles must be sharp, evenly distributed over the instrument head, retained adequately by the matrix and resist clogging.
- The concentricity of the instrument must be accurate for control of the shape and dimension of the preparation.

Factors Influencing the Cutting Efficiency of Burs

I. Influence of Design and Manufacturing:
   1. Rake angle
   2. Clearance angle
   3. Number of teeth or blades and their distribution
   4. Runout
   5. Finish of the flutes
   6. Heat treatment
   7. Design of flute ends (flute ends)
   8. Bur diameter
   9. Depth of engagement (Depth of cutting)
   10. Influence of load
   11. Influence of speed

Bur Tooth

This terminates in the cutting edge or blade. It was two surfaces, the tooth face, which is the side of the tooth on the leading edge and the back or flank of the tooth, which is the side of the tooth on the rotating edge.

Rake Angle (Fig. 30.2)

The rake angle is that the face of the bur tooth makes with the radial line from the center of the bur to the blade. This angle can be negative if the face is beyond or leading the radial line (referring to the direction of rotation).

It can be 'O' if the radial line and the tooth face coincide with each other (Radial rake angle). The angle can be positive, if the radial line leads the face, so that the rake angle is on the inside of radial line.

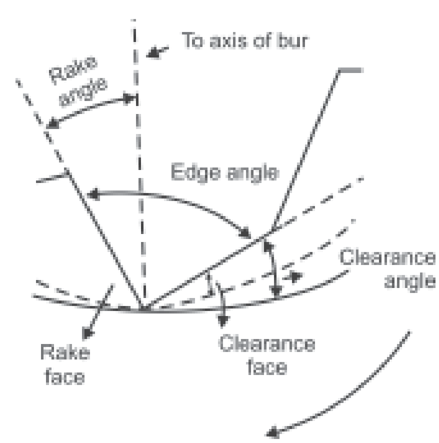


Fig. 30.2: Bur design showing different angle

Land (Figs 30.3 and 30.4)

The plane surface immediately following the cutting edge.

Clearance Angle (Fig. 30.5)

The angle between the back of the tooth and the work.

If a land is present on the bur, the clearance angle is divided into primary clearance which is the angle the land will make with work and the secondary clearance, which is the angle between the back of the bur tooth and work. When back surface of the tooth is curved, the clearance is called the radial clearance "Radial clearance".

Tooth Angle

This is measured between the face and back. If a load is present, it is measured between the face and the land.

Flute or Chip Space

The space between successive teeth. The number of teeth in dental cutting burs is usually 6 to 8.

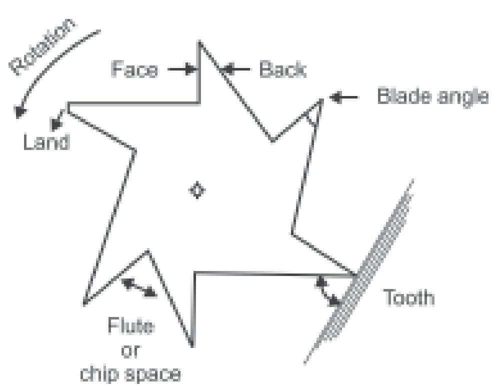


Fig. 30.3: Bur design

CUTTING EFFICIENCY IN RELATION WITH RAKE ANGLE

The more positive, the rake angle is the greater in the burs cutting efficiency. Also burs with radial rake angle cut effectively than designs with negative rake angles. However, with a negative rake angle, the cut chips moves directly away from blade edge and often fractures onto small bits or dust. This is in contrast to burs with a positive rake angle where the chips are larger and tend to clog the chip space. There are practical objections to the use of positive rake angles in dental burs particularly steel burs, because the positive rake angle decreases the

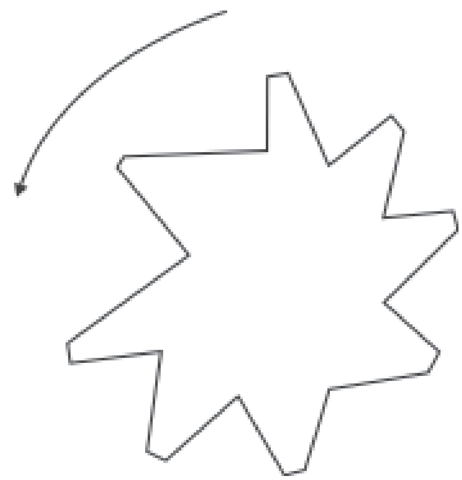


Fig. 30.4: Bur with land

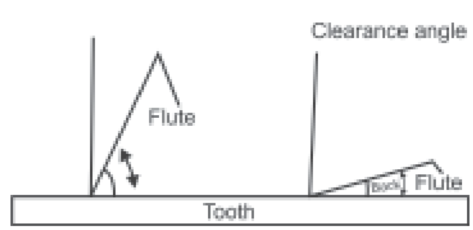


Fig. 30.5: Clearance angle

size of the bur tooth and its tooth angle, thus decreasing its bulk. As a result, there is a great possibility that the bur teeth will be curved, flattened or over fractured during cutting.

Instrument Design

Friction

Friction will occur in the moving parts of a handpiece and also with the tooth is rotating or cutting materials. If the heat from friction is not prevented or counter acted.

1. There may be pulpal reactions
2. Handpiece will be unsuitable for dental use

Torque

Torque is the ability of the handpiece to withstand lateral pressure on the revolving tool without decreasing its speed or reducing its cutting efficiency. Torque is dependent upon (1) the type of bearing used and (2) the amount of energy supplied to the handpiece.

Vibration

It is a very deleterious aspect of rotary instrumentation. While some vibration is unavoidable care should be taken not to introduce it unnecessarily.

Excessive wear of the turbine bearings, for example, will cause eccentric running which creates substantial vibration.

Cross Cuts

Cross cuts are needed on fissure burs to obtain adequate cutting effectiveness at low speeds, but at high speeds they are not needed. Because cross cut burs used at high speeds tend to produce unduly rough surfaces. Cross cuts may be in any number but usually are 6 to 8.

Concentricity

Concentricity is a direct measurement of the symmetry of the bur head itself. It measures how closely a single circle can be passed through the tips of all of the blades. Thus, concentricity is an indication of whether one blade is longer or shorter than the others. It is a static measurement not directly related to function.

Run Out

It is a dynamic test measuring the accuracy with which all blade tips pass through a single point when the instrument is rotated. It measures not only the concentricity of the head but also the accuracy with which the centre of rotation passes through the center of the head.

The average value of clinically acceptable run out is 0.025 mm.

Dental Abrasive Stones

1. Design
2. Factors affecting the abrasive efficiency of dental stones.
   a. Irregularity in shape of abrasive particles.
   b. Hardness of the abrasive material
   c. Impact strength of abrasive material
   d. Size of the abrasive particle
   e. Pressure and rpm
3. Type of Dental Stones: (Short, Regular or Long lengths) (Cylinder, Wheel, Cone, Inverted cone, tapered, Dough nut, Round, Filamentous, V-shaped, Hour glass etc.)

At present there are no standardized numbering system for dental stones.

LASER EQUIPMENT

Lasers are devices which produce beams of very high intensity of light. In dentistry, currently lasers have been used in treatment of soft tissues and the modification of hard tissues of teeth.

The word Laser is an acronym for "Light Amplification by Stimulated Emission of Radiation".

A crystal of gas is excited to emit light photons of a characteristic wavelength that are amplified and filtered to make a coherent light beam.

There are several types of lasers available depending on the wavelength.

The lasers range from long wavelength through (visible wavelengths) to short wavelengths (ultraviolet).

Excimers are special ultraviolet lasers. At the present time, CO_2 and Nd:YAG lasers have shown most promise.

Currently laser units are expensive and at the moment, lasers are used frequently in dentistry for either soft-tissue applications or hard tissue surface modification. They are not used of cavity preparation because they are inefficient and awkward in removing large amounts of enamel or dentin. these also produce intolerable amount of heat. Therefore lasers may never replace a high speed dental handpiece.

In dentistry, lasers are applied in basic research, analgesic effect by Biostimulation, and in conservative dentistry for tissue sealing caries treatment, light curing of composite resin, conditioning of tooth surface and in endodontics, lasers are used for root canal treatment and Apicectomy and in periodontics for:

- Scaling of root surface
- Excision of gingival soft tissues

Ultrasound in Dentistry

- Has many applications in the field of dentistry
- Ultrasound may be generated by either magnetostriction or piezoelectricity.
- Interaction of ultrasound with biological tissues may be caused by either thermal or mechanical mechanisms.
- The mechanical forces produced may be the result of cavitation, Acoustic microsteaming and radiation pressure forces.

Air Abrasives

Air/Powder Abrasive Systems:

Black in 1945 developed the Air abrasive system which could be used to cut enamel and dentine by the action of abrasive particle Nitrous oxide(N_2NO_3). Which were forced through a nozzle in a stream of compressed air at 80 psi.

Advantages of Air abraising over rotary methods:

1. Less generation of heat, vibration and noise.
2. Cutting was said to be more rapid with less force being applied to the tooth.

Disadvantages of Air Abrasive System were;

1. Not suitable for large carious cavities
2. Not suitable for removing of the restorations
3. Not suitable for finishing cavity surfaces
4. The air abrasive equipment was bulky and expensive.

Prophylet is an example of the air powder abrasive system that is in current use for removal of bacterial plaque and skin from enamel and root surfaces.

This type of system operates by the emission of fine particles of sodium bicarbonate ($NaHCO_3$) through a stream of air surrounded by water, but it is clearly not intended for use in cavity preparation.

BIOLOGICAL CONSIDERATIONS

Teeth are vital organs, therefore they must be treated with considerations with subject to operative procedures. The tissues to be considered are the soft is the hard tissues of the oral cavity.

Periodontium

Injury can occur from direct damage by a hand instrument or dental bur. Generally these injuries will heal. However, severe injury to periodontal fibers especially in the interproximal regions can lead to irreparable damage.

Prevention

1. Selection of speed
2. Rubber dam application
3. Correct operative procedures

Enamel

- It is composed of 92% mineral and 8% organic material are water as measured by volume.
- It is recognized as the hardest human tissue.
- It is important to understand the structural features of enamel when planning preparations, as this understanding provides the operator with basic knowledge regarding the strengths and weakness of enamel surface and cavity margins.
- Operative preparations should be designed so as to preserve enamel but at the same time provide mechanical stability and good biologic acceptance.
- Eccentric burs that do not run true in the high speed handpiece can produce crazing of the enamel.
- It dentin is removed unduly, the enamel can easily chip and break way. Therefore it is the intend of the operative dentist to strengthen the patients cavity walls by carefully cutting back the unsupported enamel until the edges are resting upon solid healthy dentin.

Dentin

Dentin is composed of 65% inorganic material, 35% organic material and water.

The remaining 35% allows dentin to be cut more readily than enamel with a dental bur.

During Cavity Preparations

When we reach the dentin layers, we should see the patient restorations because of the exposure of the dentinal tubules, patient may get sensitivity. In such cases, we should use handpiece with coolants.

Operative Precautions

The operative procedures that may have a deleterious effect upon dentin are:

1. Heat generated by cutting action from burs or polishing of restorations.
2. Undue dehydration during cutting (fluid in open dentinal tubules gets dried).

   In the light these considerations and in order to minimize these effects, the cautions the operative dentist should avoid things such as prolonged application of blasts of warm air. Removal of smear layer and desiccation of dentinal tubules.
3. Excessive cutting of tooth substance without suitable coolants especially to burs and diamond stones in the high speed handpieces or under heavy loading.

Pulp

Pulp of a tooth is unique among other body tissues organs.

- It is a very small but it is able to fulfill sensory nutritional functions of a tooth.

- It also forms additional dentin and provides a defence against infection.
- During cavity preparation, the more close to the pulp, more severe the reaction and less chance for recovery.
- A tooth preparation introduces a number of irritate factors to the pulp.

The pressure of instrumentation on exposed dentin characteristically, causes the aspiration of the nuclear the odontoblasts of the entire odontoblasts themselves nerve endings from pulp tissues into the dentinal tubular. This will obviously stimulate them, disturb their metabolism and lead to their complete degeneration and disintegration.

This can occur by excessive pressure of hand/rot instruments especially in decreased effective depths.

Sometimes, this pressure may drive some microorganism from an infected floor of wall into the pulp leading to irritation.

The type of cutting instruments used has variable irritating factors.

The depth of the cavity is the most detrimental irritating factor to the pulp.

Most important is the thickness of the dentin bridge between the floor of the cavity and the roof of the pulp chamber called the "effective depth". This should be at least 2 mm.

The less this effective depth, nearer the ingredients to the pulp, so the more destructing pulpal reactions will be.

Heat production is the 2nd most detrimental factor. If the pulp temperature is elevated by 113ºF, definitive pulpal reactions will occur even in normal vital periodontal organ.

VIBRATIONS

Vibrations are measured by amplitude of their capacity and frequency (the number per unit time) are an indication of eccentricity in rotary instruments.

The higher the amplitude is, the more destructive may be the response of the pulp. The reaction is very characteristic and is called the "rebound response". It is thought to be the result of ultrasonic energy induced and it takes the form.

1. Disruption of the odontoblast in the opposite side of the pulp chamber from where the cavity is prepared.
2. Edema
3. Fibrosis of pulp tissues proper.
4. Change in ground substance.
5. Reduction in the predentin formation all around the pul chamber.

PROTECTION

Protection of the patient, dentist and dental auxiliaries must be considered in the practice of dentistry.

The measures are:

1. If the dentist work alone, the patient can help by holding the handle of "nyman saliva ejector" after it is positioned in the mouth.

   This handy instrument accomplish three things at one time.

   a. Holds the tongue out of the way
   b. Reflects light onto lingual surfaces
   c. Serves as a saliva ejector
2. Turbine handpieces/air turbine handpieces, the rotating cutting instruments does not stop immediately when the foot control is released. The operator either must wait for the instrument to stop or be extremely careful when removing the handpiece from the mouth.
3. When we are using large discs, it should be rotated at reduced speeds and with extreme caution.
4. Use of rubber dams.

5. Use of face masks for the protection from air-borne infections like tuberculosis etc, During cutting procedures patient should avoid sudden reflex movement (Gagging, Swallowing, Coughing).
6. All should wear protective glasses to prevent eye damage. That is Patient, Dentist and chair side assistant.
7. Air contamination should be avoided by exhaust fans.

PROTECTION FROM NOISE

Normal noise level is 20 to 40 decibels.

If it is more than 40 decibels, precautionary measures should be taken.

1. Use of ear plugs
2. Use of ear phones with music
3. Loud noise should be avoided.
4. Quiet room environment should be maintained in the clinic.

NOISE

Soft music or rainfall usually of a relaxing and sedative quality.

Loud noises are generally annoying and contribute to mental and physical disorders like:

(1) Nervousness, (2) Indigestion and (3) Headache

Noisy Environment also

1. Decreases the ability to concentrate
2. Increases the accident proneness and
3. Reduces the overall efficiency.

Potential damages to hearing by noise depends upon the following criteria.

1. Intensity of loudness measured in decibels (db)
2. Frequency of vibrations measured in cycles/sec (cps)
3. Duration of the exposure measured by time
4. Susceptibility of the individual

In dental office there are many sources of noise: A certain amount of unnoticed background noise is present except in a vacuum.

For example, a "quiet" room will register from 20 to 40 db. This is known as the ambient noise level.

Water and gear driven handpieces are relatively quiet, i.e. 50 to 70 decibels of a low frequency range.

Methods to Avoid Noise Levels

1. To wear ear plugs that will provide 30 to 35 of reduction.
2. Use of handpieces that do not produce sounds of hazardous level.
3. Sound proofing can be considered when one plans to build a new office.
4. Hard objects reflect sound. Hence to absorb and break up sound waves acoustical ceiling tile, curtains or drapes at the windows and carpeting on the floor.

MAINTENANCE

1. Proper maintenance of the handpiece, i.e. Lubrication, repair etc.
2. Burs should not be left in the handpiece overnight because some steel shanks that may rust and corrode in metal checking system.

STERILIZATION AND DISINFECTION OF THE ROTARY EQUIPMENT

Definition

Sterilization

"Sterilization is the process by which an article, surface or medium is freed of all microorganisms either in the vegetative or spore state ".

(Text of Microbiology by R. Ananthanarayan and C.K. Jayaram Panicker in its 3rd edition).

Disinfection

"Disinfection means the destruction of all pathogenic organism or organisms capable of giving rise to infection".

Handpiece Surface Contamination Control

Blood and saliva contaminate the surfaces of handpieces during various treatments. Hence the handpieces should first, washed using the detergent solution. cleaned with disinfectant solution and should be autoclaved.

OTHER METHODS OF HANDPIECE STERILIZATION

Chemical Vapor Pressure Sterilization

This method recommended for some types of handpiece apparently works well with ceramic bearing handpieces may impair others.

Ethylene oxide (ETOX) gas is the most gentle method sterilization used for handpieces.

Dry heat sterilization of handpieces : is generally recommended. A rapid, high temperature, dry heat disinfection has been developed for handpieces.

Times and Temperatures for Heat sterilization:

Method	*Temperature*	*Holding time in minutes*
Autoclave	121 °C	15 minutes
	126 °C	10 minutes
	134 °C	3 minutes

1. Handpieces can be sterilized by autoclave method 121^0 15 lb pressure for 15 minutes.
2. Burs, stones and discs can be sterilized by autoclave dry heat oven. (DCNA, 1971).

These can also be disinfected by Di-phenolic and (Quarternary Ammonium Compounds), Detergents.

Low speed handpieces are sterilized by hot oil. (mineral or silicone).

Sterilization of Burs in Autoclaves

To avoid corrosion or rust, burs are most simply sterilized in a dry heat air oven or ethylene oxide gas sterilizer.

For autoclave sterilization burs can be protected by keeping them submerged in a small amounts of 2% sodium nitrate solution.

CONCLUSION

Tooth cutting with the of enamel cutters to hand drills and then to the powered equipments with the help of power, air and water.

A lot of modification has been developed for the convenience of the patient dentist and assistants. Recent advances have come for the field as use of Lasers, Ultrasonics in endodontics, Ultrahigh speeds for cavity preparations etc.

By utilizing all these technologies, conservative dentistry can be practiced efficiently and safely for the dentist, patient and the auxiliaries.

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